LIQUID FUELS FROM BIOMASS: NORTH AMERICA
IMPACT OF NON-TECHNICAL BARRIERS ON IMPLEMENTATION

Prepared For:

IEA Bioenergy Task 27

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EXECUTIVE SUMMARY

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes. The IEA Bioenergy Vision is "To realise the use of environmentally sound and cost-competitive bioenergy on a sustainable basis, to provide a substantial contribution to meeting future energy demands."

The IEA Bioenergy Mission is "To facilitate, co-ordinate and maintain bioenergy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialization of environmentally sound, sustainable, efficient and cost-competitive bioenergy technologies."

The scope of this work includes the documentation of the current usage of ethanol and biodiesel in the transportation markets in Canada and the United States. The factors that impact on this market penetration are identified. These factors include;

- Production costs of conventional fuels and biofuels. The production costs for the production of ethanol from both grains and lignocellulosics is considered.
- Alternative fuels taxation.
- Non tax financial incentives for alternative fuels.
- Environmental policies. These include agreements such as the Kyoto Protocol that address greenhouse gas emissions and national programs that address criteria air contaminants.
- Public opinions towards alternative fuels and biofuels. Are consumers willing to pay more for biofuels?
- The socio-economic impacts of biofuels. The production of feedstocks and biofuels can impact the rural economy significantly. A number of studies of socio-economic impacts of biofuels are reviewed.
- Identification of stakeholders and the driving forces of the stakeholders.
- Other factors such as standards, fuel properties, and distribution systems.

Two future biofuels scenarios are identified and analyzed, a modest increase (10%) in use over five years and a dramatic increase over ten years to 5% of the total motor fuels use. The dramatic case would result in about 3.7 billion litres of biofuels being produced and used in Canada annually and 43 billion litres being used in the United States. This assumes substitution for both gasoline and diesel fuel on an energy equivalent basis. The conclusions regarding the actions required to make each scenario a reality are identified.

There are now over five billion litres of ethanol used in gasoline in the United States and Canada each year. This represents about 1% of the gasoline volume or 0.65% of the energy in the gasoline pool. Most of the ethanol is used in low-level blends of 5-10% ethanol in gasoline, only about 0.25% of the ethanol is used as E85.

The biodiesel industry in North America is not nearly as well established as the ethanol industry. The first commercial uses of biodiesel have really occurred in 1999 and 2000. Most of the use of biodiesel prior to this time could best be classed as demonstration projects. Biodiesel in the United States is a 20% blend of a fatty acid methyl ester and petroleum diesel fuel. Biodiesel production capacity is much larger than demand at the current time. The two most common feedstocks are waste vegetable oils and animal fats and soybean oil.

The cost of producing ethanol is higher than gasoline production costs. Ethanol costs are strongly influenced by feedstock costs but in 1998 with corn costing $2.40/bushel; ethanol costs were 30 cents per litre including capital recovery. Based on crude oil at $20 per barrel, gasoline costs are about 15.5 cents per litre. In the United States a federal tax incentive of 14.3 cents per litre equalizes the price of ethanol and gasoline on a volumetric basis. Equal costs provided little incentive for expanded ethanol supply or demand. Ethanol producers can get a return of capital but not a return on capital comparable to other potential investments. Gasoline marketers can get ethanol at the same cost as gasoline but would have difficulty recovering the additional costs of handling ethanol gasoline blends. There is therefore little incentive to expand ethanol use.

The technology to produce ethanol from lignocellulosic is developing in Canada and the United States. Economic projections indicated that it is currently more expensive than ethanol from corn but that with further development it may be possible to reduce the costs below that of corn ethanol and perhaps as low as 20 cents per litre once the technology is fully developed and the industry mature.

Biodiesel production costs are even higher than those of ethanol and are even more strongly influenced by the feedstock price. There are only a few state incentives for biodiesel use and thus biodiesel has a significant economic barrier to widespread use.

Tax incentives have been extremely important to the development of the ethanol industry in North America. The federal excise tax incentive has been in place for over twenty years in the US and it is the most important of the US incentives. States incentives played a large role in the development of the industry in the 1980's but they have gradually been reduced or eliminated since then. Only a few states still provide incentives for the use or production of ethanol. As the incentives have changed so has the market for ethanol. In the 1980's ethanol was used as a volume extender and octane enhancer. In the 1990's markets for oxygen in gasoline developed, first in the winter as oxygenated gasoline to deal with high carbon monoxide levels and then all year round as reformulated gasoline to combat ground level ozone problems. The ethanol market is currently about 22%-oxygenated gasoline, 42% reformulated gasoline and 36% octane enhancer and volume extender.

In both Canada and the US there are many government programs that are supportive of ethanol development. These include research and development programs, development and demonstration initiatives, and market development incentives. The support for biodiesel is more limited. In Canada only a small amount of R&D has been done on biodiesel. There have been no significant development, demonstration or market development initiatives. In the US biodiesel R&D has been and is continuing to receive some support from the Department of Energy. There is also a small amount of market development support.

Environmental initiatives that require the addition of oxygen to gasoline have been very supportive of ethanol market development efforts in the US. No such programs exist in Canada. The general public awareness of ethanol's environmental benefits appears to be higher in Canada and have played a bigger role in market development than in the United States. Marketers have focused on this in Canada and have developed extensive information campaigns to get this message across to the public. Similar efforts appear to have been less successful in the United States. There is some evidence that some consumers will pay more for a cleaner burning fuel. In Canada there is real world experience with this to support this hypothesis but in the US there is only public opinion surveys to support the concept. It is clear in both countries that not all customers are willing to pay more.

Numerous socio-economic studies of ethanol and biodiesel production and use in various jurisdictions have been performed over the past two decades. Approximately 25 of these studies are reviewed. Most studies were related to ethanol from corn and were carried out for areas of the United States while a few were undertaken for Canada. There are a few biodiesel specific studies. There is considerable variation in the scope, approaches and methodologies applied in these studies.

Most of the analyses concluded that the extra demand for feed grains (mostly corn) had some upward impact on feed grain prices. The amount of the increase varies year by year due to changes in the overall supply-demand balance. The studies that considered the whole US market have price increases for corn of 20 to 45 cents per bushel due to the demand created by ethanol production. Due to the interdependent nature of North American feed grain markets Canadian producers have also received some benefit from this extra demand.

Most of the studies reported an increase in the number of jobs due to the production of ethanol. These jobs are weighted towards the rural sector of the economy but indirect benefits accrue to all sectors of the economy. Most of the studies also report an increase in Gross Domestic Product (GDP) related to the demand for grain and the production of ethanol. However, these results are mostly in regions that have large rural populations, and lack an oil refining industry.

The studies are not consistent in their determination of overall costs and benefits to the economy. As a result the conclusions of the reports vary with respect to the costs and benefit analyses. Some conclude that the costs to governments and society outweigh the benefits but most reach the opposite conclusion. That is, the benefits are greater than the costs and that government expenditures drop as a result of ethanol fuel tax exemptions. Some studies are also internally inconsistent in how they treat issues such as ethanol's lower energy content. They calculate the lost government revenue from the ethanol portion of fuels but do not include the extra fuel tax revenue from the extra gasoline sales caused by the lower fuel economy.

The views of stakeholders are reviewed. Not surprisingly there is a wide range of views on the desirability of biofuels. In general there is support from the agricultural sector and some of the environmental organizations and resistance from the oil sector. Support and opposition are not unanimous in any group.

Some of ethanol's technical characteristics such as its impact on gasoline vapour pressure, and the water tolerance impact on the cost of using ethanol and thus ethanol's value to a refiner or marketer. The magnitude of these costs or at least the perceived magnitude of the costs is significant in the overall system economics. Ultimately the costs are borne by the ethanol producers in the form of lower prices. Lower ethanol prices reduce the attractiveness of making investments in new production capacity.

The moderate growth scenarios are likely to be achieved for ethanol in Canada and the United States with the continuation of existing policies. Biodiesel in the US is also likely to achieve the moderate growth scenario. Biodiesel in Canada lacks a commercial champion and any market development is unlikely without such a champion.

The high growth scenarios for ethanol in North America are constrained by market access. The scenario would require 75% of all gasoline to contain 10% ethanol. Unless the economics of adding ethanol to gasoline can be dramatically enhanced gasoline marketers and refiners are not likely to use ethanol at this level willingly. Even new regulations in the United States that would require the addition of renewable fuels to the motor fuel pool envision an ethanol market of less than half the size of this high growth scenario.

In the US the high growth ethanol case is also constrained by the availability of feedstock. All of the corn exports and the entire expected yield Improvements over the ten-year period are required to meet demand. This is an unlikely case. If a large portion of the ethanol demand can be supplied from lignocellulosics the supply constraint is eliminated. This will require the continued development of the technology and may require support for the first demonstration projects as well to reduce the investment risks.

The primary critical success factors which have led to the development of the ethanol industry in North America are:

1. The support of the agricultural sector, including the individual producers, their associations and the agricultural products processors.

2. The implementation and continuation of tax incentives.

3. The regulatory requirement to add oxygen to some gasoline (US only).

These factors need to continue for the expanded biofuels use scenarios considered. The combined economic factors of feedstock cost, oil price and tax incentives will determine the rate at which ethanol is used in the market. Increased oil prices as recently experienced will likely lead to higher ethanol production and use provided feedstock prices and tax incentives remain at the same level as the past few years. The improved economics created by higher oil prices will improve the financial return of ethanol producers and encourage new producers to enter the market and allow ethanol to be priced more competitively with gasoline which in turn will encourage more ethanol use. With the well established positions on ethanol use by the major oil companies, economics alone are not likely to encourage enough gasoline marketers to use ethanol so that the high market scenario could be achieved.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BTU	British Thermal Units Energy. To convert to kJ multiply BTU by 1.055
bu	Bushel
CGSB	Canadian General Standards Board
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2 Equivalent	Weighted sum of CO_2, CH_4 and N_2O emissions using the weighting GWP factors defined below.
DOT	Department of Transportation
EIA	Energy Information Administration
EPAct	Energy Policy Act
E85	Eighty-five % ethanol, 15% gasoline
g	Gram
gal	US gallon (3.785 L)
GHG	Greenhouse gases
GJ	Gigajoule (10^9 Joules)
GWP	Global warming potential over a 100 year period: CO_2, 1; CH_4, 21; N_2O, 310
HHV	Higher heating value of a fuel (combustion moisture as liquid)
ICE	Internal Combustion Engine
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
k	Prefix for thousand
km	Kilometre
kWh	Kilowatt-hour
L or l	Litre
lb.	Pound (0.4536 kg)
M	Prefix for million, when used with metric unit
m^3	Cubic metre, 1000 litres
mi	Mile (1.609 km)
MM	Million when applied to an imperial unit of energy
mpg	Mile per United States gallon
NBB	National Biodiesel Board
NMOG	Non-methane organic gases
NRCan	Natural Resources Canada
N_2O	Nitrous oxide
NO_x	Oxides of nitrogen
PM	Particulate matter
ppm	Parts per million by volume
RFG	Reformulated gasoline
S	Sulphur
SCF	Standard Cubic Feet (60F, 14.7 psia)
t	Tonne (1000 kg)
THC	Total hydrocarbon
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
USDA	US Department of Agriculture
USG	United States Gallon
VOC	Volatile organic compounds, excluding methane and ethane

1. INTRODUCTION

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes. The IEA Bioenergy Vision is “To realise the use of environmentally sound and cost-competitive bioenergy on a sustainable basis, to provide a substantial contribution to meeting future energy demands.”

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As of January 2000, nineteen countries or organisations, designated by their governments, take part in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Italy, Japan, The Netherlands, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, the USA and the European Commission. Work in IEA Bioenergy is carried out through a series of Tasks, each having a defined work programme. Each participating country pays a modest financial contribution towards administrative requirements, shares the costs of managing the Tasks and provides in-kind contributions to fund participation of national personnel in the Tasks.

1.1 TASK 27 LIQUID BIOFUELS

The objectives of this Task are to:

- Work jointly with governments and industry to identify and eliminate non-technical environmental and institutional barriers which impede the use of liquid fuels from biomass in the transportation sector;
- Establish an Advisory Board of stakeholders in the Liquid Biofuels industry to bring a business environment to the work of the Task;
- Identify remaining technological barriers to Liquid Biofuels technologies and recommend strategies for overcoming these barriers;
- Consolidate these efforts and formulate a deployment strategy that will include agreement to proceed with a technology demonstration unit to be cost-shared by government and industry at the termination of the Annex.

This project is designed to further the first objective by providing detailed information and analysis on liquid biofuels implementation in North America.

1.2 SCOPE OF WORK

The scope of work includes the documentation of the current usage of ethanol and biodiesel in the transportation markets in Canada and the United States. The factors that impact on this market penetration are identified. These factors include;

- Production costs of conventional fuels and biofuels. The production costs for the production of ethanol from both grains and lignocellulosics is considered.
- Alternative fuels taxation.
- Non tax financial incentives for alternative fuels.
- Environmental policies. These include agreements such as the Kyoto Protocol that address greenhouse gas emissions and national programs that address criteria air contaminants.

- Public opinions towards alternative fuels and biofuels. Are consumers willing to pay more for biofuels?
- The socio-economic impacts of biofuels. The production of feedstocks and biofuels can impact the rural economy significantly. A number of studies of socio-economic impacts of biofuels are reviewed.
- Identification of stakeholders and the driving forces of the stakeholders.
- Other factors such as standards, fuel properties, distribution systems.

The detailed information that is collected is analyzed to identify the critical factors that have enabled biofuels in a particular region or conversely are impeding the expansion of a biofuels industry. The most significant policies that have impacted industry development are identified.

Two future biofuels scenarios are identified and analyzed, a modest increase (10%) in use over five years and a dramatic increase over ten years to 5% of the total motor fuels use. The dramatic case would result in about 3.7 billion litres of biofuels (2.9 billion litres of ethanol and 0.8 billion litres of biodiesel) being produced and used in Canada annually and 43 billion litres (37 billion litres of ethanol and 6 billion litres of biodiesel) being used in the United States. This assumes substitution for both gasoline and diesel fuel on an energy equivalent basis. The conclusions regarding the actions required to make each scenario a reality are identified.

The work covered in this report covers two countries with different currencies and different measurement systems. Unless otherwise noted the financial information is presented in US dollars and the metric system is used.

2. BACKGROUND

Ethanol has been used as a motor fuel in North America since the early 1900's. In 1908 Henry Ford designed his Model T to run on ethanol. Ethanol gasoline blends were used in parts of the United States prior to the Second World War but through the 1950's and 1960's there was no ethanol used in gasoline in North America. In 1979 the US Congress established the federal ethanol program to stimulate the rural economy and reduce the dependence on imported oil. The production and use of ethanol as a motor fuel in the United States and in Canada has increased continuously since that time.

There are now over five billion litres of ethanol used in gasoline in the United States and Canada each year. This represents about 1% of the gasoline volume or 0.65% of the energy in the gasoline pool. Most of the ethanol is used in low-level blends of 5-10% ethanol in gasoline, only about 0.25% of the ethanol is used as E85.

In North America fuel ethanol is currently produced mostly from starch containing crops such as corn, wheat and milo. There are several plants that use a waste sugar stream from another industrial plant such as a sulphite pulp mill, a brewery, cheese factories, potato processors and other food processing plants. The dominant feedstock is corn. There are plans to introduce new technology to convert lignocellulosic materials to ethanol. The first of these plants are expected to be built in the next several years.

The basic process involves the enzymatic hydrolysis of starch to sugars and the fermentation of the sugars to ethanol via yeast. The weak ethanol solution known as beer is then distilled and dried to produce anhydrous ethanol, which is suitable for blending with gasoline. There are a number of process variations that are employed such as dry or wet milling, batch or continuous fermentation, etc. There are about 60 operating ethanol plants in North America.

Standards for fuel ethanol are well developed in the United States and Canada. The standards are evolving as gasoline standards change and become more restrictive. There are some differences in the standards for fuel ethanol between Canada and the United States although the differences have not impacted on cross border trade in ethanol.

The biodiesel industry in North America is not nearly as well established as the ethanol industry. The first commercial uses of biodiesel have really occurred in 1999 and 2000. Most of the use of biodiesel prior to this time could best be classed as demonstration projects. Biodiesel in the United States is a 20% blend of a fatty acid methyl ester and petroleum diesel fuel. Biodiesel production capacity is much larger than demand at the current time. The two most common feedstocks are waste vegetable oils and animal fats and soybean oil. Substantial effort has been put into developing standards for biodiesel in the United States and the ASTM has released a provisional specification.

2.1 ETHANOL

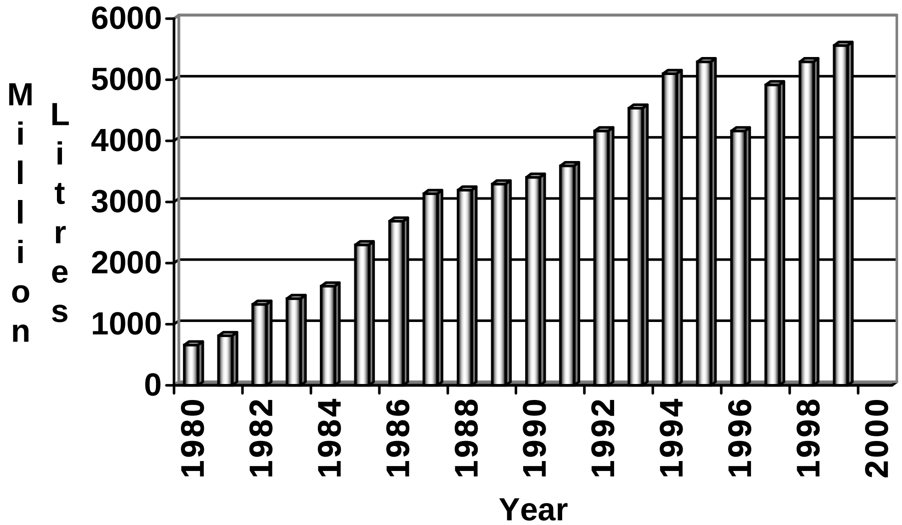
2.1.1 Markets

This section documents the fuel ethanol market in the United States and in Canada since 1979. Ethanol is used in both low-level blends (less than 10%) and in high level blends (more than 85%). The data on each market segment is presented separately where available.

2.1.1.1 United States

Ethanol production for use as a gasoline blending component began with 38 million litres produced in 1979. The production has grown to 5.3 billion litres in 1999. In the first eight months of 2000 the production is running 11.9% ahead of 1999. The growth is shown in the following figure. (Renewable Fuels Association and Energy Information Administration)

Figure 2-1 Ethanol Production in the United States



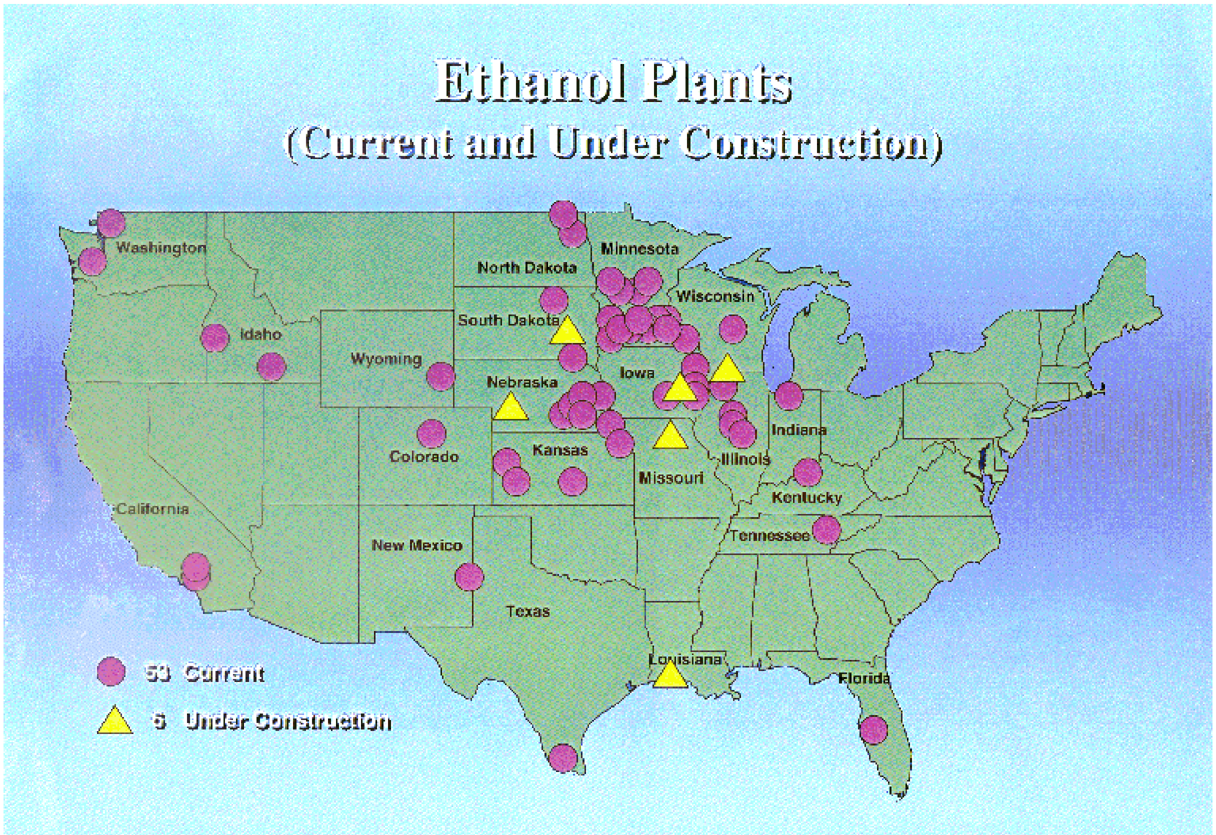
The reduction in production in volume in 1996 was due to very high corn prices, which made the production and sale of ethanol uneconomic. The ethanol is produced in 58 plants located in 18 states. In Table 2-1 the US ethanol producers and the plants under construction are identified (Bryan and Bryan, May 2000). There are plans for an additional 2.4 billion litres/year from 22 plants that are not yet under construction but are at various stages of development. In Figure 2-2 the geographic distribution of the operating and under construction plants is shown. The information in the table and the figure are from different sources and different times, which accounts for the small difference in number of plants in each category.

Table 2-1 US Ethanol Producers

Company	Location	Feedstock	Production Capacity million litres/year
A.E. Staley	Loudon, TN	Corn	170
AGP	Hastings, NE	Corn	197
Agri-Energy	Luverne, MN	Corn	64
Alchem	Grafton, ND	Corn	40
Al-Corn	Claremont, MN	Corn	40
Archer Daniels Midland (total capacity)	Decatur, IL	Corn	2,835
	Peoria, IL	Corn	
	Cedar Rapids, IA	Corn	
	Clinton, IA	Corn	
ADM Corn	Walhalla, ND	Corn/Barley	106
Broin Enterprises	Scotland, SD	Corn	26
Cargill (total capacity)	Blair, NE	Corn	378
	Eddyville, IA	Corn	
Central Minnesota	Little Falls, MN	Corn	64

Chief Ethanol	Hastings, NE	Corn	234
Chippewa Valley Ethanol	Benson, MN	Corn	72
Corn Plus	Winnebago, MN	Corn	68
DENCO, LLC.	Morris, MN	Corn	57
ESE Alcohol	Leoti, KS	Corn	4
Ethanol 2000	Bingham Lake, MN	Corn	57
EXOL, Inc.	Albert Lea, MN	Corn	57
Georgia-Pacific	Bellingham, WA	Sulphite liquor	26
Golden Cheese	Corona, CA	Whey	11
Gopher State Ethanol	St. Paul, MN	Corn	57
Grain Processing Corp.	Muscatine, IA	Corn	38
Heartland Corn Products	Winthrop, MN	Corn	64
Heartland Grain Fuel	Aberdeen, SD	Corn	30
	Huron, SD	Corn	53
High Plains Corp. (total capacity)	York, NE	Corn	265
	Colwich, KS	Corn/Milo	
	Portales, NM	Corn	
J.R. Simplot (total Capacity)	Caldwell, ID	Potato waste	23
	Burley, ID	Potato waste	
Jonton Alcohol	Edinburg, TX	Corn	5
Kraft, Inc.	Melrose, MN	Whey	11
Manildra Ethanol	Hamburg, IA	Corn/Milo/Wheat starch	26
Merrick/Coors	Golden, CO	Waste beer	6
Midwest Grain (total capacity)	Pekin, IL	Corn/wheat starch	408
	Atchison, KS	Corn/wheat starch	
Minnesota Clean Fuels	Dundas, MN	Waste sucrose	6
Minnesota Corn Processors (total capacity)	Columbus, NE	Corn	416
	Marshall, MN	Corn	
Minnesota Energy	Buffalo Lake, MN	Corn	45
New Energy Corp.	South Bend, IN	Corn	321
Northeast MO Grain Processors	Macon, MO	Corn	57
Pabst Brewing	Olympia, WA	Brewery waste	3
Parallel Products (total capacity)	Louisville, KY	Beverage waste	45
	Bartow, FL	Beverage waste	
	Rancho Cucamonga, CA	Beverage waste	
Permeate Refining	Hopkinton, IA	Sugars & starches	6
Pro-Corn	Preston, MN	Corn	64
Reeve Agri-energy	Garden City, KS	Corn/milo	38
Sunrise Energy	Blairstown, NE	Corn	26
Sutherland Associates	Sutherland, NE	Corn	57
Williams Energy	Pekin, IL	Corn	378
	Aurora, NE	Corn	113
Wyoming Ethanol	Torrington, WY	Corn	19
Total			**7,086**
Plants Under Construction			
Golden Triangle	St. Joseph, MO	Corn	95
Adkins Energy	Lena, IL	Corn	113
Lake Areas Corn Processors	Wentworth, SD	Corn	151
City Brewery	La Crosse, MI	Corn	76
Total			**437**

Figure 2-2 US Ethanol Plants



Ethanol for low-level blends has three distinct markets in the United States. It can be used as a gasoline extender or octane booster, it can be used as an oxygen compound in the winter oxygenated fuels programs and it can be used in the Reformulated Gasoline (RFG) Program. The first market usually uses 10% ethanol, the winter oxygenated fuels market can use either 10% ethanol or 7.7% ethanol (2.7% wt oxygen) and the third program is likely to use 5.7% ethanol, which corresponds to 2.0% wt oxygen. This oxygen content is the minimum required in the reformulated gasoline regulations.

The Federal Highway Administration of the US Department of Transportation collects data from the individual states on the use of ethanol gasoline blends. The data separates 10% blends from blends using less than 10% ethanol. The data from the past five years is summarized in the following table. Data is collected in different formats in each of the states so the information is estimated only.

Table 2-2 Use of Ethanol in Gasoline 1995 – 1999

Year	Total Ethanol Used in Gasoline	Gasoline with 10% Ethanol	Gasoline with less than 10% Ethanol	Total
	Thousand litres	Thousand litres	Thousand litres	Thousand litres
1994	3,938,579	33,504,045	8,112,220	41,616,265
1995	4,587,771	39,315,296	10,174,675	49,489,971
1996	4,067,586	29,564,178	16,270,073	45,834,250
1997	5,023,371	37,835,060	17,736,123	55,571,179
1998	4,901,980	39,644,307	13,195,416	52,839,724

In 1998 there were reductions in ethanol use at less than 10% in a number of states. In some of these, such as Washington, Virginia, North Carolina, and New Mexico the blends were increased to 10% and the amount of ethanol increased from 1998 to 1999. The largest drop in use in 1999 was in California. According to the 1998 data ethanol is being used in 35 states and the District of Columbia.

The DOT 1998 data on use by state is presented in the following table. The states are presented in order of consumption. It is known that ethanol blends are sold in both Idaho and Wyoming yet no data is reported for those states. State Authorities estimated that 22.6 million litres of ethanol was used in Idaho in 1998 and 18.9 million litres in Wyoming the same year (Cheminfo, 2000).

Table 2-3 Estimated Use of Ethanol by State 1998

STATE	Total Ethanol Used	10% Blends	Less than 10% Blends	Total Ethanol Blends
	Thousand L	Thousand L	Thousand L	Thousand L
Illinois	802,003	8,020,041	-	8,020,041
Ohio	801,851	8,018,525	-	8,018,525
Minnesota	751,290	3,756,443	4,878,498	8,634,941
Iowa	258,725	2,587,253	-	2,587,253
California	238,915	-	4,191,468	4,191,468
Texas	234,904	2,304,345	58,046	2,362,391
Colorado	223,160	930,847	1,689,278	2,620,122
Indiana	214,655	2,146,560	-	2,146,560
North Carolina	144,672	1,446,723	-	1,446,723
Virginia	136,515	1,365,132	-	1,365,132
Michigan	125,307	1,253,062	-	1,253,062
Washington	123,829	1,181,518	73,714	1,255232
Wisconsin	122,215	1,222,150	-	1,222,150
New Mexico	99,486	994,847	-	994,847
Nebraska	74,750	747,491	-	747,491
South Dakota	67,998	679,999	-	679,999
Arizona	62,790	-	815,467	815,467
New York	58,526	314,288	351,826	666,214
Oregon	52,425	491,914	41,988	533,902
Nevada	52,213	151,234	481,678	632,912
Pennsylvania	48,970	489,707	-	489,707
Utah	44,071	221,054	285,254	506,308
New Jersey	32,527	103,640	287,847	391,487
Missouri	28,044	280,450	-	280,450
North Dakota	17,184	171,827	-	171,827

Alaska	14,848	95,173	-	95,173
Kentucky	13,990	139,905	-	139,905
Kansas	12,425	124,245	-	124,245
Alabama	12,153	121,523	-	121,523
Connecticut	12,115	90,750	39,497	130,247
Maryland	8,993	89,930	-	89,930
Florida	5,205	52,062	-	52,062
Louisiana	2,397	23,961	-	23,961
Montana	1,554	14,957	760	15,717
Tennessee	1,194	11,941	-	11,941
West Virginia	79	801	-	801
Arkansas	-	-	-	-
Delaware	-	-	-	-
Vermont	-	-	-	-
Dist. of Col.	-	-	-	-
New Hampshire	-	-	-	-
Rhode Island	-	-	-	-
Georgia	-	-	-	-
South Carolina	-	-	-	-
Hawaii	-	-	-	-
Idaho	22,680[1]	-	-	-
Oklahoma	-	-	-	-
Maine	-	-	-	-
Massachusetts	-	-	-	-
Mississippi	-	-	-	-
Wyoming	18,900[1]	-	-	-
Total	4,901,980	39,644,307	13,195,417	52,839,724

Ethanol is also used as a blend of 85% ethanol and 15% gasoline in flexible fuel vehicles and in some demonstration programs where 95% ethanol blends are used in diesel type engines. Most of this fuel use is located in the US Mid-West. The Energy Information Administration in the report “Alternatives to Traditional Transportation Fuels 1998” has estimated the consumption of E85 and E95 from 1992 to 2000. That data is presented in the following table.

Table 2-4 Estimated Consumption of E85 and E95

	E85 Consumption	E95 Consumption
Units	Thousand litres E85	Thousand litres E95
1992	110	465
1993	249	438
1994	416	767
1995	990	5,451
1996	3,621	14,791
1997	6,672	6,226
1998	9,008	321
1999	12,981	321
2000	17,123	321

The consumption of E85 is increasing at as rapid rate as refuelling facilities are constructed to supply fuel to the several hundred thousand flexible fuel vehicles that have been produced in

[1] State Authority estimate for 1998. Not included in totals.

North America over the past few years. The increase and decline in the used of E95 reflects the demonstration nature of the fuel. There are no new vehicles being built and existing demonstrations are being phased down. The use of high level ethanol blends accounts 0.25% of the ethanol used as a motor fuel in the United States.

There have been recent demonstrations of ethanol diesel blends and emulsions in the United States. There is no commercial application of this technology at this time.

2.1.1.2 Canada

Ethanol use as a blending component of gasoline began in the Province of Manitoba in 1981 with a 10% ethanol blend being marketed. In 1987 ethanol blends with 5% ethanol were offered in the four Western Canadian provinces with about 250 service stations offering the fuel. In 1992 ethanol blends were introduced into Ontario and in 1995 in Quebec. Today there are approximately 1000 service stations in six Provinces offering 5% or 10% blends of ethanol and gasoline.

There are no commercial programs for high level ethanol blends in Canada. There are demonstrations for E85 for flex fuel vehicles. There are no heavy-duty applications for E95 type fuels in Canada.

Statistics on ethanol use in fuel are not readily available. The Federal Government Interdepartmental Steering Committee on Ethanol (1998) reported that in 1997 the domestic ethanol production for fuel was 28-30 million litres per year with about 12 million litres per year imported to meet a total demand of 40 million litres per year. With the start up of the Commercial Alcohols Inc. plant in late 1997 and the expansion of ethanol retailing in Ontario that accompanied this plant there is now about 150 million litres of fuel ethanol produced in Canada and used in Canada each year. There continues to be trade with the United States in ethanol.

The existing producers of anhydrous ethanol suitable for blending with gasoline and their production capacities are shown in the following table.

Table 2-5 Ethanol Production in Canada

Company	Location	Capacity	Comments
Mohawk Canada Inc.	Minnedosa, Manitoba	10 million litres/year	Started 1981. Wheat Feedstock.
Pound Maker Agventures Ltd.	Lanigan, Saskatchewan	13.5 million litres/year	Started 1990. Wheat Feedstock. Integrated Feedlot.
Commercial Alcohols Inc.	Tiverton, Ontario	20 million litres/year	Started 1988. Corn Feedstock. 7 million litres for fuel.
Commercial Alcohols Inc.	Chatham, Ontario	150 million litres/year	Started 1997. Corn Feedstock. 120 million litres for fuel.
API Grain Processors	Red Deer, Alberta	26 million litres/year	Started 1998. Wheat Feedstock. Mostly exported.

Western Canada is an exporter of fuel ethanol to the United States with most of the production of the API plant being exported. Eastern Canada is an importer of fuel ethanol both as ethanol and in some cases blended with the gasoline. Statistics Canada maintains a database on trade statistics. Trade between Canada and the United States in denatured ethanol is shown in the following table for the past five years. The category includes denatured ethanol in accordance with the specifications of the Canada Excise Act and Regulations. It is indicative of the magnitude of the trade.

Table 2-6 Canadian US Trade in Denatured Ethanol - Statistics Canada

	Imports into Canada	Exports to the United States
Units	Litres/year	Litres/year
1995	11,741,847	-
1996	21,693,313	-
1997	21,315,002	374,666
1998	9,881,285	1,671,218
1999	11,075845	3,756,244

The exports to the United States show some growth that is consistent with the start up of a plant in Western Canada that did export fuel ethanol. The import data would appear to be low. Industry Canada also maintains an online database of trade data. The Industry Canada database yields exactly the same information for the exports but considerably different data for the imports. The Industry Canada data is only available for the dollar value of the imports and not the volume. This data is shown in the following table along with the estimated volume extrapolated from the Statistic Canada unit prices.

Table 2-7 Canadian US Trade in Denatured Ethanol - Industry Canada

	Imports into Canada	Estimated Imports into Canada
Units	Thousand Dollars	Litres/year
1995	8,447	15,000,000
1996	13,546	25,000,000
1997	12,407	23,400,000
1998	15,394	29,000,000
1999	30,374	60,000,000

It is known that the plant at Chatham, Ontario experienced operating problems early in 1998 and for the last eight months of 1999. This would probably account for the higher level of imports in 1998 and 1999. It is estimated that the total demand for fuel ethanol in Canada is approximately 170 to 180 million litres per year. 150 million litres per year is produced in Canada and 20-30 million litres per year is imported from the United States. There may be a small amount of ethanol blended gasoline that is imported into Canada as gasoline and is not identified as such in the trade statistics.

2.1.2 Standards

Specifications for both fuel ethanol and ethanol gasoline blends have been developed in both Canada and the United States over the past 20 years. The specifications are quite similar with only minor differences such as in the level of denaturants required to satisfy government authorities in each country. There is trade in ethanol between the countries so at least some ethanol producers have been able to adapt their production to meet the specifications in each country. The following sections describe the role of various agencies and groups in the standards developing process in each country.

2.1.2.1 United States

In the United States a number of organizations have a role in determining fuel ethanol quality and specifications. The US Bureau of Alcohol, Tobacco and Firearms sets minimum standards for denaturing fuel grade ethanol. High taxes ($13.50 US/proof gallon) are imposed on ethanol that is not properly denatured. The minimum denaturant required for formula 20 is 2 gallons of gasoline per 100 gallons of ethanol. The standard practice in the US is 5 gallons of gasoline per 100 gallons of ethanol.

The American Society for Testing and Materials (ASTM) is a consensus standards developing organization. It has developed a standard for denatured ethanol for blending with gasoline ASTM D4806-9. The relevant properties of this standard are shown in Table 2-8.

Table 2-8 ASTM Fuel Ethanol Specifications

Property	Limit
Ethanol, vol. %	92.1
Water, vol. %	1.0 max
Methanol, mg/L	0.5 max
Acetic Acid, wt %	0.007
Chlorine, mg/L	40 max
Copper, mg/l	0.1 max
Denaturants, Vol. %	1.96 –4.76

The ASTM has also developed standards for gasoline including gasoline with ethanol. The most current version is ASTM D4814-00. The United States Environmental Protection Agency has limits on gasoline volatility, lead and phosphorus contents, and the use of oxygenates. The level of ethanol is limited to 10% by volume.

Individual states have the ultimate responsibility for gasoline quality. Many states do reference the ASTM specifications. In California there are currently discussions underway to define limits on sulphur, benzene, olefins and aromatic content of denatured ethanol. These limits will ensure that when ethanol is added to California gasoline designed for ethanol blending the resultant finished gasoline will still meet California clean burning gasoline requirements. The proposed limits are shown in the following table.

Table 2-9 Proposed California Limits on Denatured Ethanol

Parameter	Proposed Limit
Sulphur, ppm	10-15
Benzene, vol. %	0.05
Olefins, vol. %	0.50
Aromatics, vol. %	1.7

2.1.2.2 Canada

The production, distribution and sale of undenatured and denatured ethanol is regulated by the Federal government's Canada Customs and Revenue Agency. The primary concern of this group is the collection of excise tax on undenatured ethanol ($11.06 Can/litre). Denatured ethanol grade 2F (DAG 2F) contains a minimum of 1% by volume unleaded gasoline and is exempt from the excise tax. It is this grade that is used for fuel ethanol in Canada.

The Canadian General Standards Board (CGSB) develops fuel specifications in Canada. This group is composed of producers, users and consumers and undertakes to develop standards by consensus. The group developed a standard (CAN/CGSB 3.511-93) for ethanol blended gasoline in the late 1980's and has updated the specification from time to time as gasoline specifications have changed. Fuel quality in Canada is a Provincial Government responsibility unless it impacts health and some but not all Provinces have adopted the CGSB specifications for gasoline and ethanol gasoline blends. In other provinces the gasoline quality is unregulated and essentially set by the fuel suppliers. The federal Government has some specifications on gasoline components that do impact health such as lead, benzene, and sulphur. The same limits apply to gasoline and ethanol blended gasolines. The CGSB specifications for ethanol are shown in Table 2-10. The specifications for ethanol gasoline blends are essentially the same as for gasoline.

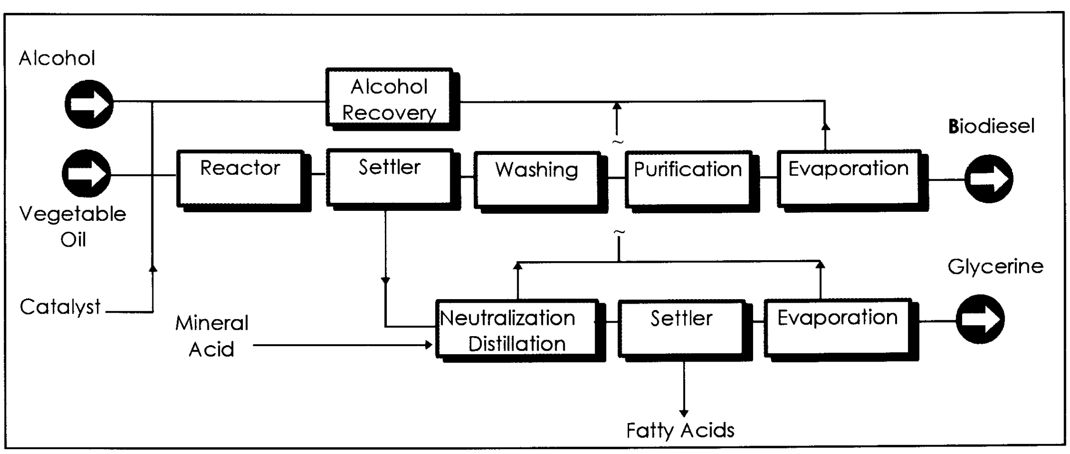
Table 2-10 Fuel Ethanol Specifications in Canada

Property	Limit
Water, wt %	1.0 max
Acetic Acid, mg/L (without detergents)	30 max
Acetic Acid, mg/L (with detergents)	42 max
Chlorine, mg Cl/L	10 max
Copper, mg Cu/L	0.1 max
Denaturants, Vol. %	5 max

2.2 BIODIESEL

Biodiesel is an ester produced by chemically reacting vegetable or animal fat with an alcohol, usually methanol. As the name implies it has properties similar to diesel fuel except it is made from renewable resources. The production process is simple and efficient. The basic process flow is shown in Figure 2-3.

Figure 2-3 Biodiesel Process Schematic



Biodiesel can be used in conventional diesel engines in its neat form or blended with conventional diesel fuel. One common blend in the United States is 20% biodiesel and 80% petroleum diesel

(B20). It can also be used as an additive to enhance the lubrication properties of petroleum diesel fuel.

2.2.1 Markets

2.2.1.1 United States

Interest in biodiesel production and use in the United States resulted in the formation of the National Soydiesel Development Board in 1992. The name of this group was later changed to the National Biodiesel Board (NBB). Some quantities of biodiesel were produced in non-dedicated plants as early as 1992. This product was used for research and demonstration programs. The NBB along with other interested organizations has succeeded in having biodiesel and B20 classified as an alternative fuel under the amended Energy Policy Act of 1992 (EPAct) that requires government fleets to purchase alternative fuel vehicles or credits for a certain percentage of their fleet. These activities have resulted in 1999 seeing the first commercial uses of biodiesel.

In the summer of 1999 two large petroleum distributors began offering premium diesel fuel with a component of biodiesel at a number of distribution terminals throughout the US Mid-West. The exact amount of biodiesel in these blends is not identified in the distributors data sheets but both distributors have included the word Soy in the name of their products. There have been other distributors who have announced the availability of B20 fuels throughout the United States. Some of these have large multi-state operations and others are small local distributors. The NBB identified 25 fleets that were using B20 for EPAct compliance as of October 1999.

Unlike ethanol there are not yet any official US Government statistics on the amount of biodiesel sold in the United States. The United Soybean Board (1999) estimated that 3 thousand tonnes of soyoil were used for biodiesel production in 1999. Soyoil is not the only source of biodiesel with some plants designed to process waste oils and fats. It has been reported by industry sources (New Fuels & Vehicle Report) that the current biodiesel production is between 7.5 and 26 million litres per year.

The production capacity of biodiesel plants is not necessarily indicative of production activity and some biodiesel is produced in non-dedicated facilities. Some of the facilities may be producing methyl esters for applications other than fuel and many are not operating at capacity. Industry sources (New Fuels & Vehicle Report) suggest that the total production capacity in the United States is 945 million litres per year. The following table provides data on some of the higher profile biodiesel producers.

Table 2-11 Biodiesel Production Capabilities, United States

Name	Location	Capacity	Feedstock
Griffin Industries	Butler, Kentucky	5.7 million L/year	Waste Oil & Grease and animal fats
NOPEC	Lakeland, Fl	18.9 million L/year	Waste Oil & Grease
Pacific Biodiesel	Kahului, Hawaii	567,000 L/year	Waste Oil & Grease
Ag Environmental	Lenexa, Kansas	22.7 million L/year	Soybeans
West Central Co-operative	Ralston, Iowa	680,000 L/year	Soybeans
Columbus Foods	Chicago, Illinois	5.7 million L/year	
World Energy	Quincy, Mass	113.4 million L/year	

2.2.1.2 Canada

Biodiesel has not been used commercially or in significant demonstration programs in Canada to date. Agricultural groups such as the Canadian Renewable Fuels Association, The Ontario Soybeans Growers' Marketing Board and the Saskatchewan Canola Development Commission have advocated the production and use of biodiesel.

The one small demonstration program in Canada involved hydro-treated tall oil. The tall oil is a waste stream from the wood pulping industry. Hydrotreating this material produces normal paraffins with high cetane ratings that can be used as diesel fuel blending agents. One disadvantage of the material is its poor cold weather properties, which limit its use to summer diesel fuels or requires the addition of cold flow improvers.

2.2.2 Standards

Biodiesel standards have been under development in the United States for the past five years.

2.2.2.1 United States

The National Biodiesel Board in the United States has expended considerable effort over a number of years to develop a national standard for biodiesel. They have been working with ASTM and in 1999 ASTM published a provisional standard (PS 121) for biodiesel. The intention of the specification is to cover the biodiesel component used for blending with diesel fuels. This standard is valid for a two-year period while necessary data is being gathered for a full standard. Efforts are currently underway to validate the precision and bias of the necessary test methods for the publication of a full standard. The relevant properties of the ASTM biodiesel standard are shown in Table 2-11. The specifications are independent of the type of vegetable oil used in the process and of the alcohol used for esterification.

Table 2-12 Provisional ASTM Standard for Biodiesel

Property	Units	Limits
Flash Point	C	100.0 min
Water & Sediment	% vol.	0.050 max
Kinematic Viscosity, 40C	mm^2/sec	1.9 – 6.0
Sulphated Ash	% mass	0.020 max
Sulphur	% mass	0.050 max
Copper strip corrosion		No. 3 max
Cetane		40 min
Carbon residue	% mass	0.050 max
Acid number	mg KOH/gm	0.80 max
Free glycerine	% mass	0.020 max
Total glycerine	% mass	0.240 max

2.2.2.2 Canada

There has been no standards development activity in Canada for biodiesel. In the spring of 2000 there was a proposal put forward to develop a standard for biodiesel similar to the ASTM work in the United States. This proposal was rejected as unnecessary and it was determined that the biodiesel blend would just have to meet the existing standard for petroleum diesel fuels.

3. COSTS OF ALTERNATE AND CONVENTIONAL FUELS

A key driver in the adoption of any alternative is the cost relative to the product being replaced. In the case of transportation fuels, this relative cost can be quite variable since not only does the cost of the traditional fuels gasoline and diesel vary widely with the swings in crude oil prices the price of the biofuels ethanol and biodiesel is also dependent on the cost of agricultural raw materials which also vary significantly and on a different cycle to crude oil prices.

The costs of producing ethanol and biodiesel are identified and analyzed in this section. The components that make up the costs are identified and the variation in production costs over time is presented. For ethanol production costs, various feedstocks are considered such as corn in the United States, feed wheats in Canada and the projected costs for ethanol produced from lignocellulosic feedstocks. Similar feedstock cost data is shown for the potential biodiesel feedstocks in the United States.

Gasoline costs are primarily a function of crude oil prices but there are other factors such as location, product quality, location, supply and demand balances and local competition issues that also impact the price. Examples of these price variations over time are presented.

Comparisons are made between the prices of ethanol and gasoline over the past fifteen years. The comparisons provide evidence of the profitability of producing ethanol and using it as a gasoline-blending component.

3.1 ETHANOL

The capital and operating costs for ethanol are presented separately in the following sections. The treatment of capital costs is the method chosen by the group of consultants working on the projects to provide consistency and comparability between the countries studied.

3.1.1 Capital Costs

In 1999 the USDA initiated a benchmarking survey of the US industry to determine production costs across the industry. Shapouri (2000) has reported preliminary results of this benchmarking survey. He reported the capital costs at the time of start up for the 28 plants included in his survey. The capital costs ranged from $0.28 to $0.63 per litre. The plants were probably built over a twenty-year time period, which makes comparison difficult. The current capital cost for a dry mill facility was estimated to be $0.33 to $0.40 per litre (Urbanchuk, 2000).

Shapouri reported that expansion costs ranged between $0.09 and $0.23 per litre. Urbanchuk estimated expansion costs at $0.16 to $0.20 per litre. Expansion costs are obviously highly dependent on the facility and the degree to which a plant is being expanded.

There have been improvements in plant construction costs over time. During the 1980's capital costs over $0.53 per litre were common whereas in 2000 plants are being built for $0.40 per litre in 2000 dollars. This equates to about a 50% reduction in capital costs when the impacts of inflation are considered.

The ethanol plants in the United States have a variety of ownership types such as farmer owned co-operatives, traditional co-operatives, investor owned, public companies, limited partnerships which means that there is no single way of treating the capital costs on an income statement. For the purposes of the study a capital recovery factor of 0.15 will be applied to the capital costs. This is equivalent to a ten-year term and an eight percent interest rate.

With a current capital cost of $0.33 to $0.40 per litre the annual capital recovery factor becomes $0.05 to $0.06 per litre. This will be added to the cash production costs of the next sections to determine the total production costs.

3.1.2 Current Production Costs - Corn

In North America ethanol is produced from a number of cereal grains, including corn, barley, wheat and milo and from waste streams from pulp mills, breweries, cheese plants, potato processors and finished food processors. The production volumes from corn plants dominate the market. In the following table the results for corn dry milling for 1998 are shown. Some of the individual costs are interpolated from Shapouri's verbal presentation and formal paper.

Table 3-1 Production Costs for Ethanol from a Corn Dry Mill Plant

Parameter	**Costs**
	US Cents per Litre
Feedstock Cost	23.3
Co-product credit	10.6
Net Feedstock cost	**12.7**
Fuel costs	2.4
Electricity cost	1.1
Total Energy Cost	**3.5**
Enzymes	1.1
Yeast	0.25
Chemicals	0.7
Denaturant	0.7
Total Chemicals	**2.7**
Maintenance	1.9
Labour	1.0
Administration	1.0
Other	1.1
Total Cash Cost	**23.9**
Capital cost recovery	**5.0**
Total Costs	**28.9**

The reported ethanol yield for a dry mill plant was 2.63 USG/bu. This would suggest that the 1998 corn cost was $2.31/bu. ($82.70/t). Shapouri reported that a corn wet mill had a total production cost of 0.5 cents/litre lower than a dry mill. Net feedstock costs that were 1.6 cents per litre lower for wet mills were offset by operating costs that were 1 cents per litre higher. The net result was only 0.5 cents per litre difference in production costs.

3.1.3 Changes in Production Costs – Corn

The efficiency of the industry has improved considerably over the past twenty years. There has been an almost continual improvement in yeast and enzyme technology that has resulted in higher ethanol yields and more energy efficient production. In 1987 the Economics Research Service of the US Department of Agriculture (USDA 1989) studied ethanol production, this data can be compared to the recent benchmarking study to confirm the improvements that have been made in ethanol production technology and costs. The comparison of cash production costs for dry mills from the two studies is shown in Table 3-2. The cost data has not been corrected for inflation.

Table 3-2 Improvements in Ethanol Production Costs, 1987- 1998

	1987	1998	% Change
Units	Cents/litre	Cents/litre	
Energy	4.9	3.5	-29.2
Ingredients	2.2	2.7	22.9
Personnel and Maintenance	4.9	2.9	-40.8
Management, Admin, Insurance & Taxes	1.3	1.0	
Other	-	1.1	
Total	13.2	11.2	-15.5

It can be seen that with the improvements in technology and operating experience gained over time the costs declined by 15.5% over a ten-year period in spite of generally rising prices. If the 1987 data is converted to 1998 dollars the reduction in production costs becomes 41.1%.

Feedstock costs vary from year from year depending on the overall supply and demand situation for the crop. The variation in feedstock prices can have a very significant impact on ethanol profitability. The following table[2] shows the average corn prices, distillers dried grain price and the net feedstock cost from 1984 to 1999. Net feedstock prices varied from 6.7 to 26.6 cents per litre. This is equivalent to a $32/barrel change in the price of oil.

Table 3-3 Feedstock and Co-Product Prices

Year	Corn	Distillers Dried Grains	Net Feedstock Cost
Units	$/tonne	$/tonne	Cents/litres
1984	126.00	165.64	18.6
1985	106.7	101.01	18.8
1986	82.69	126.82	20.6
1987	68.12	131.69	6.7
1988	94.89	159.81	11.2
1989	100.01	157.19	12.7
1990	100.01	146.60	13.6
1991	99.22	147.01	13.3
1992	93.71	135.60	12.8
1993	95.29	127.51	13.9
1994	97.25	131.84	14.0
1995	106.70	114.73	17.7
1996	158.68	167.69	26.6
1997	109.85	139.90	16.5
1998	92.13	93.84	15.7
1999	78.75	91.43	12.5

3.1.4 Production Costs – Wheat

In Western Canada wheat is being used as the feedstock for ethanol plants since corn is not generally available in the region. Wheat has a slightly lower starch content and a higher protein

[2] Information Resources, Inc. Motor Fuels Pricing Data, www.petrochem.net/doc/MOTDT/doc/pricing/corn/corn_his.htm

and fibre content than corn. This results in lower ethanol yields but higher yields and higher protein content in the distillers' grains. The lower quality feed wheats that are used for ethanol production generally cost slightly more than corn but have a higher co-product value than corn which results in usually lower net feedstock costs. The cash production costs for a typical small (10 to 25 million litre/year) ethanol plant in western Canada are shown in Table 3-4. The feedstock data has been normalized to 1998 so that it can be compared to the US corn data presented earlier. The data has been obtained from industry sources. It should be recognized that the US data is for larger plants than those in Canada that this data was obtained from.

Table 3-4 Production Costs for Wheat Ethanol in Canada

Parameter	**Costs for Wheat**	**Costs for US Corn**
	US Cents per Litre	US Cents per Litre
Feedstock Cost	22.2	23.3
Co-product credit	11.9	10.6
Net Feedstock cost	**10.3**	**12.7**
Fuel costs	4	2.4
Electricity cost	1	1.1
Total Energy Cost	**5.0**	**3.5**
Enzymes, Chemicals, yeast	2.2	2.0
Denaturant	0.4	0.7
Total Chemicals	**2.6**	**2.7**
Maintenance	3.2	1.9
Labour	4	1.0
Administration	0.7	1.0
Other	0.3	1.1
Total Cash Costs	**26.2**	**23.9**

In spite of the different plant sizes and the different feedstocks the cost data is quite similar.

3.1.5 Lignocellulosic Ethanol

Ethanol can be produced from lignocellulosic materials as well as from starch and sugar crops. The advantages of lignocellulosic ethanol are derived from the utilization of an abundant resource that has limited market opportunities at present. The disadvantage is that the processes are more complex and difficult and at the present time would result in higher production costs than ethanol derived from starch or sugar crops.

The US Department of Energy's Office of Fuels Development has a very large and active program devoted to the conversion of biomass to ethanol. This program involves in-house research, subcontracts and co-operative research and development agreements with industrial partners, universities and national laboratories. More detail is provided in a later section on R&D support.

There are several companies developing lignocellulosic ethanol projects with assistance from the US DOE, these include BC International with a 75 million litre a year project in Jennings LA. processing bagasse and rice straw, Masada Resource Corporation with a 36 million litre per year facility in Middleton NY processing municipal solid waste and Arkenol with a proposed project in California processing rice straw.

In Canada Iogen Corporation is building a commercial demonstration plant in Ottawa that will be capable of processing 60 tonnes per day of agricultural residues into ethanol.

3.1.5.1 *Capital Costs*

The capital costs for ethanol produced from lignocellulosic feedstocks are difficult to confirm. There are no commercial plants in production in North America and the process developers are not willing to make public their projected production economics at this stage of their development. The most recent and comprehensive assessment was published by NREL (1999). This report was done in conjunction with a commercial ethanol plant developer so the capital cost estimates are current for the assumed process configuration.

The capital cost estimates are at the conceptual level given that the complete process is still in development. The authors made the best possible attempt to develop cost estimates that were consistent with applicable engineering and construction practices for facilities of this type. The estimates were also made for an n^{th} plant so that design risk and uncertainty have been minimized.

The feedstock chosen for the plant was yellow poplar since this is the feedstock that has been used for most of the experimental work. The choice of feedstock will impact the capital cost with the biggest impact being in the feedstock handling portion of the process.

A number of scenarios have been modeled based on the current understanding of the process and on potential developments in pretreatment, enzyme productivity and hydrolysis. The 2015 case also relied on modified feedstock with a higher cellulose and lower lignin content.

The results summary for current and futuristic scenarios is shown in the following table.

Table 3-5 Lignocellulosic Ethanol Capital Costs

	Near Term Base Case	Near Term, Best of Industry Case	Future Case Year 2005	Future Case Year 2010	Future Case Year 2015
Raw Material	2,000 tpd	2,000 tpd	2,000 tpd	2,000 tpd	2,000 tpd
Ethanol Yield	283 L/t	316 L/t	337 L/t	391 L/t	466 L/t
Ethanol Production	198 million L/Y	221 million L/y	236 million L/y	274 million L/y	326 million L/y
Total capital Cost	$234 million	$205 million	$169 million	$156 million	$159 million
Per Unit Cost	$1.18/L	$0.93	$0.72	$0.57	$0.49
Capital Recovery	$0.177/L	$0.139/L	$0.107/L	$0.085/L	$0.073/L

3.1.5.2 *Production Costs*

The projected production costs for ethanol produced from lignocellulosic feedstocks are developed from the same NREL publication but using the capital cost structure used for this report. The feedstock is assumed to be delivered to the plant for $27.50 per tonne, which is the same assumption used by NREL and is a value that has been commonly used in Canada for the cost of agricultural residues. NREL have also assumed that for an n^{th} plant the feedstock will be agricultural resources such as switchgrass or corn stover.

The projected production costs are shown in the following table.

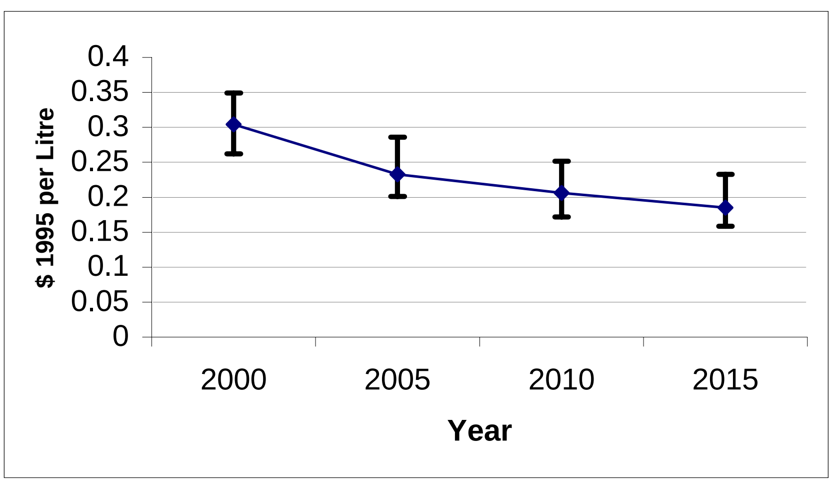
Table 3-6 Lignocellulosic Ethanol Production Costs

	Near Term Base Case	Near Term, Best of Industry Case	Future Case Year 2005	Future Case Year 2010	Future Case Year 2015
Feedstock Cost	$0.097	$0.087	$0.082	$0.070	$0.059
Co-Product Credit	$0.019	$0.029	$0.030	$0.013	$0.0
Chemicals	$0.049	$0.049	$0.039	$0.027	$0.028
Labour	$0.013	$0.011	$0.010	$0.009	$0.008
Maintenance	$0.024	$0.019	$0.014	$0.011	$0.010
Insurance & taxes	$0.018	$0.015	$0.010	$0.008	$0.007
Cash Cost	**$0.182**	**$0.152**	**$0.125**	**$0.112**	**$0.112**
Capital Recovery	$0.177/L	$0.139/L	$0.107/L	$0.085/L	$0.073/L
Total Cost	**$0.359**	**$0.291**	**$0.232**	**$0.197**	**$0.185**

The near term, best of industry case for an n^{th} plant is approximately the same production cost as the current cost for producing ethanol from corn. The initial plants that process biomass to ethanol will be more expensive than shown here since they are likely to be smaller and be more conservatively designed in order to minimize the risk of introducing new technology.

There is still a great deal of uncertainty surrounding these values. There has been a sensitivity analysis performed on the basic NREL data. Ferrell (2000) presented the results. The feedstock pricing was varied with a lower limit set with feedstock at $17.5/tonne and an upper limit set with feedstock at $40/tonne. The price projections are shown in the following figure.

Figure 3-1 Price Projections for Lignocellulosic Ethanol – Enzyme Process



The improvements in 2005 and 2010 are expected to come from enzyme and ethanologen performance. The improvements projected for 2015 are derived from genetically engineered feedstocks.

3.1.6 Ethanol Selling Prices

The ethanol market in the United States is a strong dynamic market with many sellers and buyers. Ethanol selling prices therefore respond to a number of variables including corn prices, gasoline prices, tax incentives and basic supply and demand issues. Information Resources Inc. reported that the average ethanol selling price for 1998 on the gulf coast was $0.281/litre. Prices in the mid west were slightly higher. In 1998 many plants were able to meet their financial obligations but some may not have covered all of their debt costs.

Ethanol producers are usually unwilling to sell ethanol for extended periods of time below their cash production costs. This then sets a floor on the ethanol selling price, which will move up and down with the net corn costs.

The buyer sets the upper limit on ethanol selling prices. Ethanol is used in three markets, as a gasoline extender, as a source of octane, or as a source of oxygen in RFG or winter oxyfuel programs. The price that a buyer is willing to pay varies according to the market. The extender market must be priced equivalent to gasoline plus tax incentives; the other markets may pay a small premium to this depending on the overall supply and demand balance.

The ethanol selling prices[3] over time are shown in Table 3-7. Ethanol prices do vary somewhat by location. The data shown in the table is for the US Gulf coast and is usually one of the lowest priced areas for ethanol in the United States.

Table 3-7 Ethanol Selling Prices – United States

Year	Ethanol
Units	Cents /litre
1984	41.0
1985	39.4
1986	27.8
1987	28.6
1988	28.3
1989	30.2
1990	32.3
1991	30.2
1992	32.8
1993	28.6
1994	30.2
1995	29.1
1996	36.0
1997	31.5
1998	27.8
1999	26.2

The situation in mid 2000 is somewhat unique with historically low corn prices and thus low ethanol production costs and historically high gasoline prices. The ethanol selling prices are high enough to give the ethanol plants a strong profit and yet are priced lower than gasoline plus tax incentives so there is a strong incentive to use ethanol. Production levels are setting monthly records in the United States. The following table presents the prices at various points in the supply chain in 1998 and the situation in June 2000.

[3] Information Resources, Inc. Motor Fuels Pricing Data, www.petrochem.net/doc/MOTDT/doc/pricing/mtbe/oxy_his.htm

Table 3-8 Prices in the Ethanol Supply Chain

	Average 1998	June 2000
	Cents/litre	Cents/litre
Net Corn Cost	12.7	10.6
Ethanol Cash Cost	23.9	21.7
Ethanol Total Cost	28.9	26.7
Ethanol Selling Price	28.1	33.1
Ethanol Plant Profit	-0.8	6.4
Ethanol cash margin	4.3	11.4
Net Ethanol Cost After Fed Incentive	13.9	18.8
Gasoline, Regular wholesale	14.3	26.5
Gasoline extender margin	-0.4	7.7

The situation in Canada is quite different than in the United States. Most ethanol production is contracted directly to gasoline refiners or marketers. Ethanol prices more closely follow gasoline prices plus incentives. As the market develops in Canada it is likely to become closer to the US market. There is already free trade in ethanol and gasoline across the border and in time the pricing is likely to be much closer than it is today.

3.1.7 Resources for Ethanol Production

North America is a significant exporter of cereal grains to the rest of the world. Grain production in both Canada and the United States has been growing steadily for many years due mostly to higher annual yields as a result of more productive varieties. In both countries there are also significant quantities of waste lignocellulosic materials generated from agricultural production. In the next section the size of these two resources is quantified and put into context of energy consumed in the countries.

3.1.7.1 Starch Crops

The primary crops of interest are corn in the US and Canada and feed wheats in Canada. In Table 3-9 the basic supply and disposition data for the crops is presented. The primary domestic use of both corn and wheat is for animal feed. In addition to the basic supply and demand balance the continual improvement in corn and wheat yields increases the supply each year. In the US the corn supply increases by approximately 3.6 million tonnes per year (1.5%) which is sufficient to grow the ethanol industry by 25% per year without impacting existing domestic consumption or exports. A similar situation exists in Canada with wheat.

Table 3-9 Cereal Grain Supply and Disposition 1998/99

Crop	Supply	Domestic use excluding fuel	Domestic fuel use	Exports
units	tonnes	tonnes	tonnes	tonnes
US Corn[4]	239,700,000	177,650,000	14,095,000	50,158,730
Canadian Corn[5]	8,910,000	8,388,000	300,000	Net zero
Canadian Wheat[6]	24,076,000	7,840,000	67,000	14,723,000

4 National Corn Growers Association. World of Corn 1999.
5 Ontario Corn Growers Association. www.ontariocorn.org/supply.html
6 Agriculture Canada. Canadian Grain and Oilseeds Outlook. July 4, 2000.

Cereal grains that are used to make ethanol also produce high protein animal feeds that tend to back out the direct use of corn or wheat as animal feed. What is more, the high protein animal feed is a better animal feed and it will back out 1.5 to 2 times as much of the original grain from the animal diet. There is clearly sufficient resource available in both countries for the modest growth case (10% over five years) considered for this report. This would be supplied by a combination of the growth in production expected from higher annual yields, diversion of some feedstock from animal feeding and diversion of some exports.

The more aggressive growth case for Canada would require about 7.3 million tonnes of wheat or about 50% of current exports. For the United States the aggressive case would require about 92.5 million tonnes of corn or almost twice the level of current corn exports. Even if all of the expected increase in corn yield over a ten-year period was dedicated to ethanol, that growth and the exports would only meet 96% of the feedstock requirement. There would be some corn diverted from animal feed by either of these scenarios but the fact remains that that the aggressive growth case is not likely to be achievable in the United States and perhaps even Canada without the development and use of ethanol from lignocellulosic technologies.

3.1.7.2 Lignocellulosics

Sheehan (2000) has recently reported on the status of lignocellulosic feedstock in the United States. The feedstocks considered were; forest residues, mill residues, urban wood wastes, agricultural residues and bioenergy crops. The availability of these resources is also strongly dependent on the price paid for them. The data from Sheehan's paper is summarized in the following table.

Table 3-10 Lignocellulosic Feedstock Availability – United States

Feedstock	Total Quantity	Total Available	Comments
Forest Residue	41 million dry tonnes	41 million t	$30/t
Mill Waste	82 million dry tonnes	1.5 million t	Mostly utilized today. $30/t
Urban Wood Waste	33 million dry tonnes	22 million t	$18/t. Lowest cost resource
Agricultural Residues	300 million dry tonnes	140 million t	Assumes some required for soil quality. $30 –50/t
Bioenergy Crops	165 million dry tonnes	165 million t	Up to $50/t

The total amount of feedstock available of 370 million tonnes is potentially enough to make 140 billion litres or more than three times the amount required for the aggressive scenario.

In Canada there are all the same potential sources of lignocellulosic feedstocks. There has not been the same one source look at the availability as has been done for the United States. The concept of removing forest residues has not been seriously considered in Canada for many years. This is probably because forests are not as intensively managed as they are in the United States. Mill waste availability was estimated by Groves (1998) to be 5 million tonnes (dry). Most of this was in the Province of British Columbia and represents softwoods and bark. Considering whitewood only and those regions that have sufficient quantity to supply a plant the availability drops to about 1.1 million tonnes. The technology for conversion of this material to ethanol is not as well developed as for hardwoods and agricultural residues. Levelton (1999) reviewed the potential resource availability of lignocellulosics for ethanol production. The summary table from that report is shown below. There is more uncertainty over the size of the resource in Canada than Sheehan expressed for the US.

Table 3-11 Resource Availability of Lignocellulosics - Canada

Source	Amount (tonnes)	Cost (Can $/t)	Potential Ethanol Production
Sawmill residue	1.1 million	20	385 million litres
Agricultural residue	12–20 million	30-40	4.5 – 7.5 billion litres
Crops from marginal land	40–80 million	50-100	15 - 30 billion litres

The resource availability is more than adequate for the aggressive target of 2.9 billion litres per year of ethanol provided the technology can de demonstrated on a commercial scale.

3.2 BIODIESEL

The biodiesel industry in North America is just beginning to become commercially established. As a result there is very little information available in the public domain concerning the commercial practices of the industry. The following information is derived mostly from US Government sources.

3.2.1 Production Costs

Production costs of biodiesel are strongly dependent on the cost of the oil feedstock. Withers (1996) reported on the production costs for an 8.7 million litre per year plant processing canola oil. Their production costs are shown in the following table.

Table 3-12 Biodiesel Production Costs

	Costs per litre
Esterification cost	$0.15
Plant Overhead	$0.09
Oil Cost	$0.53
Co-product credit	$0.10
Total cost	$0.67

The use of yellow grease rather than soyoil could reduce the production cost to $0.37 per litre. This is substantially above the pre-tax price of diesel fuel and without any substantial tax incentive explains the low market penetration of biodiesel in North America.

3.2.2 Resource Availability

Duffield et al (1998) identified the total quantity of vegetable oils and animal fats produced in the United States each year. For the major products the levels of exports were also identified this data is shown in the following table. The mass of oil produced has been converted to volume using a 0.92 kilogram per litre conversion for ease of comparison to diesel fuel.

Table 3-13 Supply of Potential Biodiesel Feedstocks

Oil Type	Oil Production		Exports
	Thousand tonnes	Million litre	Million litres equivalents
Vegetable			
Soybean	6,788	7,331.7	983
Corn	944	1,019.1	393
Cottonseed	555	598.8	132
Sunflowerseed	395	426.0	340
Canola	160	173.1	0
Peanut	128	138.3	26
Flaxseed/linseed	80	85.8	0
Safflower	54	57.8	0
Rapeseed	1	1.5	0
Total vegetable	**9,105**	**9,832.1**	**1,874**
Animal Fat			
Lard	466	503.5	60.5
Edible tallow	677	731.4	147.4
Inedible tallow	1,647	1,778.5	1,066
Yellow grease	1,196	1,292	166.3
Total animal fat	**3,987**	**4,306.2**	**1,440**
Total supply	**13,092**	**14,138.3**	**3,314**

These oils and fats are already used for the manufacture of some industrial products. About 10.6% of domestic production is used for industrial products including soaps, cosmetics, surfactants, lubricants, paints, solvents, resins, stabilizers, emulsifiers, pesticides and fatty acids. The 3.3 billion litres represented by the exported oils represents 3.1% of the 106 billion litres of diesel fuel consumed in the United States each year.

These feedstocks are relatively expensive. The average prices for the period 1993-1995 were reported by Duffield and are shown in the following table.

Table 3-14 Oil and Fats Prices, 1993-1995

Oil or Fat	Prices, $/litre
Yellow grease	0.23
Inedible tallow	0.27
Lard	0.35
Edible tallow	0.38
Soybean	0.47
Corn	0.51
Cottonseed	0.51
Sunflowerseed	0.51
Rapeseed	0.55
Canola	0.60
Flaxseed/linseed	0.60
Safflower	0.60
Peanut	0.71

From an economic and resource availability perspective yellow grease and inedible tallow would be the most attractive feedstocks for biodiesel in the United States.

The Canadian production of oilseed crops (canola, soybeans, and flaxseed) ranges from 8 to 10 million tonnes per year. Given the current yields, the suitable land base and crop rotational requirements there is very little potential for increased production of oilseeds in Canada. The oilseeds are grown primarily for the oil content which has a value of two to four times that of the protein on a weight basis. Most of this oil was used for high value human consumption markets in Canada or the United States. Approximately four million tonnes of this crop are exported as seed and as much as 900,000 tonnes are exported as oil. About three quarters of the exports are canola or canola oil. The primary market for the seed is Japan and the United States for the oil.

The canola seed has an oil content of approximately 40%, double that of soy oil, so there is the equivalent of 1.6 million tonnes of oil exported as seed. The maximum potential resource, if one considers all of the exported material for diversion to the fuel market is 2.5 million tonnes of oil (2.7 billion litres of oil).

One kilogram of oil produces one kilogram of methyl ester or 1.13 litres of biodiesel. If the oil currently being exported was produced in Canada and converted to biodiesel there would be the potential to produce 2.8 billion litres of biodiesel each year. Total Canadian annual consumption of diesel fuel is 14.5 billion litres. The potential for substitution of biodiesel is about 20%, which coincidentally is the blend of biodiesel and conventional diesel being used in the United States. In most urban areas of Canada waste cooking oils and animal fats are collected and processed into animal feed and feedstocks for chemical processes. There is very little information available on quantities that might be available for biodiesel production but it is unlikely that the availability of this material would make a significant difference to the market penetration potential.

3.3 Conventional Fuels

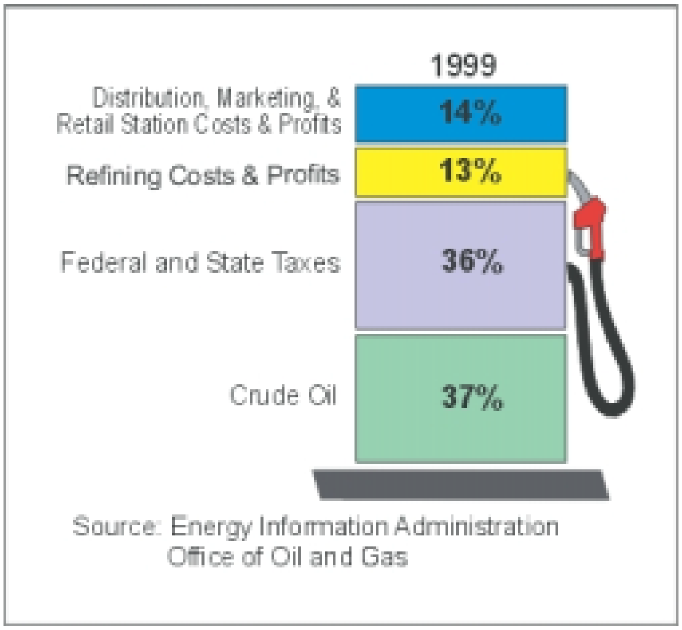
The US Energy Information Administration produced a brochure entitled “A Primer on Gasoline Prices”, the following section is derived mostly from that brochure.

Gasoline, one of the main products refined from crude oil, accounts for just about 20 percent of the energy consumed in the United States. The primary use for gasoline is in automobiles and light trucks. Gasoline also fuels boats, recreational vehicles, and various farm and other equipment. While gasoline is produced year-round, extra volumes are made in time for the summer driving season. Gasoline is delivered from oil refineries mainly through pipelines to a massive distribution chain serving about 180,000 retail gasoline stations throughout the United States. There are three main grades of gasoline: regular, midgrade, and premium. Each grade has a different octane level. Price levels vary by grade, but the price differential between grades is generally constant.

The cost to produce and deliver gasoline to consumers includes the cost of crude oil to refiners, refinery processing costs, marketing and distribution costs, and, finally, the retail station costs and taxes. The prices paid by consumers at the pump reflect these costs, as well as the profits (and sometimes losses) of refiners, marketers, distributors, and retail station owners.

In 1999, when the price of crude oil averaged $110.07 per cubic metre, crude oil accounted for about 37% of the cost of a gallon of regular grade gasoline (Figure 3-2). The share of the retail price of regular grade gasoline that crude oil costs represent varies somewhat over time and among regions. For example, on the West Coast, crude oil represented about 31% of the price of gasoline in 1999, while on the Gulf Coast, it represented 39%.

Figure 3-2 The Cost Components of Gasoline



Federal, State and local taxes are a large component of the retail price of gasoline. Taxes (not including county and local taxes) account for approximately 36 percent of the cost of a gallon of gasoline. Within this national average, Federal excise taxes are 4.87 cents per litre and State excise taxes average 5.28 cents per litre. Also, seven States levy additional State sales taxes, some of which are applied to the Federal and State excise taxes. Additional local county and city taxes can have a significant impact on the price of gasoline.

Distribution, marketing and retail station costs and profits combined make up 14% of the cost of a gallon of gasoline. Only 28% of service station outlets today are company stations, i.e., are owned or leased by a major oil company and operated by its employees. Nearly 72% are operated by independent dealers free to set their own prices. The price on the pump reflects both the retailers' purchase cost for the product and the other costs of operating the service station. It also reflects local market conditions and factors, such as the desirability of the location and the marketing strategy of the owner.

Even when crude oil prices are stable, gasoline prices normally fluctuate due to factors such as seasonality and local retail station competition. Additionally, gasoline prices can change rapidly due to crude oil supply disruptions stemming from world events or domestic problems, such as refinery or pipeline outages.

Seasonality in the demand for gasoline - When crude oil prices are stable, retail gasoline prices tend to gradually rise before and during the summer, when people drive more, and fall in the winter. Good weather and vacations cause U.S. summer gasoline demand to average about 5% higher than during the rest of the year. Prices during the summer typically show a 3.5 cent-per-gallon increase, even after correcting for changes in crude oil prices.

Changes in the cost of crude oil - Events in crude oil markets were a major factor in all but one of the five run-ups in gasoline prices between 1992 and 1997, according to the National Petroleum Council's study U.S. Petroleum Supply - Inventory Dynamics.

Crude oil prices are determined by world-wide supply and demand, with significant influence by the Organization of Petroleum Exporting Countries (OPEC). Since it was organized in 1960, OPEC has tried to keep world oil prices at its target level by setting an upper production limit on its members. OPEC has the potential to influence oil prices world-wide because its members possess such a great portion of the world's oil supply, accounting for nearly 40% of the world's production of crude oil and holding about 67% of the world's estimated crude oil reserves.

Rapid gasoline price increases have occurred in response to crude oil shortages caused by, for example, the Arab oil embargo in 1973, the Iranian revolution in 1978, the Iran/Iraq war in 1980, and the Persian Gulf conflict in 1990. The most recent gasoline price increases are due in part to OPEC crude oil production cuts in 1999. In addition, higher demand from a recovering Asian economy caused more competitive bidding for crude oil supplies in the international market and was a contributing factor to an increase in gasoline prices in 1999.

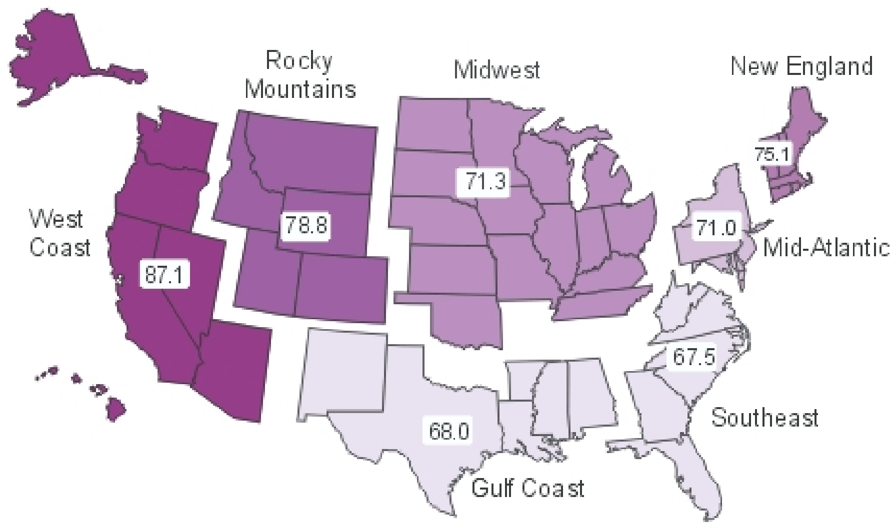
Product supply/demand imbalances - A continuing economic boom in the United States has led to greater demand for gasoline. If demand rises quickly or supply declines unexpectedly due to refinery production problems or lagging imports, gasoline inventories (stocks) may decline rapidly. When stocks are low and falling, some wholesalers become concerned that supplies may not be adequate over the short term and bid higher for available product. Such was the case in late summer 1997, as a demand surge drained gasoline stocks and prices rose rapidly.

Gasoline may be less expensive in one summer when supplies are plentiful vs. another summer when they are not. These are normal price fluctuations, experienced in all commodity markets. For example, the price of corn is higher than normal just before harvest time because corn inventories are depleted at that time. Prices may remain high after the harvest if a drought occurred during the growing season, thereby limiting the supply of corn. Or prices may decline when a healthy crop is produced.

However, prices of basic energy (gasoline, electricity, natural gas, heating oil) are generally more volatile than prices of other commodities. One reason is that consumers are limited in their ability to substitute between fuels when the price for gasoline, for example, fluctuates. So, while consumers can substitute readily between food products when relative prices shift, most do not have that option in fuelling their cars.

Although price levels vary over time, Energy Information Administration (EIA) data indicate that average retail gasoline prices tend to be typically higher in certain States or regions than in others (Figure 3-3). Prices shown are per gallon and do not include taxes.

Figure 3-3 Motor Gasoline Prices at Retail Outlets, 1999 Average Regular Grade



Source: Preliminary data from the Energy Information Administration's *Petroleum Marketing Monthly*, Table 31.

Aside from taxes, there are other factors that contribute to regional and even local differences in gasoline prices:

Proximity of supply - Areas farthest from the Gulf Coast (the source of nearly half of the gasoline produced in the U.S. and, thus, a major supplier to the rest of the country) tend to have higher prices. The proximity of refineries to crude oil supplies can even be a factor, as well as shipping costs (pipeline or waterborne) from refinery to market.

Supply disruptions - Any event that slows or stops production of gasoline for a short time, such as planned or unplanned refinery maintenance, can prompt bidding for available supplies. If the transportation system cannot support the flow of surplus supplies from one region to another, prices will remain comparatively high.

Competition in the local market - Competitive differences can be substantial between a locality with only one or a few gasoline suppliers versus one with a large number of competitors in close proximity. Consumers in remote locations may face a trade-off between higher local prices and the inconvenience of driving some distance to a lower-priced alternative.

Environmental programs - Some areas of the country are required to use special gasolines. Environmental programs, aimed at reducing carbon monoxide, smog, and air toxics, include the Federal and/or State-required oxygenated, reformulated, and low-volatility (evaporating more slowly) gasolines. Other environmental programs put restrictions on transportation and storage. The reformulated gasolines required in some urban areas and in California add three and five cents, respectively, to the price of conventional gasoline served elsewhere.

Operating costs - Even stations co-located have different traffic patterns, rents, and sources of supply that influence retail price.

The following table documents the price of gasoline at the rack and at retail in the United States from 1994 to 2000. The rack prices are representative of refinery gate prices. Very large purchasers will be able to purchase gasoline at a small discount to rack. The data is from the Energy Information Administration, Petroleum Marketing Monthly. The data for 1984 to 1993 includes all grades of gasoline, since some premium gasoline is included the values are higher than for regular gasoline. The data for 1994 to the present is shown for regular, oxygenated and reformulated gasoline. Since the data does not include taxes the impact of the ethanol tax incentive is not shown in the oxygenated and reformulated gasoline columns. The gap in rack and retail prices between regular and oxygenated gasoline will be narrower after the incentive is accounted for.

Table 3-15 Gasoline Prices 1994 to 2000 in the United States (ex Tax)

Date	Regular Rack	Oxygenated Rack	Reformulated Rack	Regular Retail	Oxygenated Retail	Reformulated Retail
	Cents/litre	Cents/litre	Cents/ litre	Cents/ litre	Cents/ litre	Cents/ litre
1984	22.0			24.0		
1985	22.1			24.1		
1986	14.0			16.5		
1987	15.6			17.7		
1988	15.3			17.8		
1989	17.3			20.0		
1990	20.8			23.4		
1991	18.5			21.1		
1992	17.9			20.8		
1993	16.6			20.1		
1994	14.4	15.5	15.1	18.2	19.7	20.2
1995	15.1	16.7	16.0	18.8	20.3	19.8
1996	17.6	19.0	18.5	21.1	23.0	22.1
1997	17.2	19.2	18.0	20.7	23.4	22.0
1998	12.5	14.4	13.5	16.2	18.2	17.7
1999	15.7	17.2	16.9	18.8	21.1	21.2
2000						
Jan	19.8	21.2	20.3	23.0	24.3	23.7
Feb	22.8	23.9	22.9	25.1	26.3	25.3
Mar	24.8	26.2	26.1	28.3	30.1	30.5
Apr	21.4			26.6		
May						
Jun						

The table clearly shows the variability in the wholesale and retail prices of gasoline with time. The cost of reformulated gasoline is apparent from the table and is generally 0.5 to 1.0 cents per litre at the rack and 1.0 to 2.0 cents per gallon at retail.

The retail margins vary from 3.0 to 4.0 cents per litre for regular gasoline and from 3.5 to 4.0 cents per litre for reformulated gasoline.

The Canadian gasoline market behaves similarly to the US market although it is less complex with only regular gasoline being available. There still exist all of the local and regional factors that contribute to price variability.

3.4 SUMMARY OF ETHANOL AND GASOLINE COSTS

The data from the previous sections is summarized in Table 3-16. This table shows the net corn prices, the ethanol selling prices, the US Federal tax exemption, and the regular gasoline wholesale price for the years 1984 to 1999. It does not show the impact of State incentives for the production or use of ethanol. These were significant in the 1980's and still exist in a few locations.

Table 3-16 Summary of Ethanol and Gasoline Costs

Date	Net Corn Cost	Ethanol Selling Price	Ethanol Production Margin (Selling Price - Corn Cost)	Regular Gasoline Rack	Federal Tax Incentive	Gasoline Blending Margin
	Cents/litre	Cents/litre	Cents/litre	Cents/litre	Cents/ litre	Cents/ litre
1984	18.6	41.0	22.4	22.0	15.9	-3.1
1985	18.8	39.4	20.6	22.1	15.9	-1.4
1986	20.6	27.8	7.2	14.0	15.9	2.1
1987	6.7	28.6	21.9	15.6	15.9	2.9
1988	11.2	28.3	17.1	15.3	15.9	2.9
1989	12.7	30.2	17.5	17.3	15.9	3.0
1990	13.6	32.3	18.7	20.8	15.9	4.4
1991	13.3	30.2	17.1	18.5	14.3	2.6
1992	12.8	32.8	20.0	17.9	14.3	-0.6
1993	13.9	28.6	14.7	16.6	14.3	2.3
1994	14.0	30.2	16.2	14.4	14.3	-1.5
1995	17.7	29.1	11.4	15.1	14.3	0.3
1996	26.6	36.0	9.4	17.6	14.3	-4.1
1997	16.5	31.5	15.0	17.2	14.3	0.0
1998	15.7	27.8	12.1	12.5	14.3	-1.0
1999	12.5	26.2	13.7	15.7	14.3	3.8
2000						
Jan	13.7	33.6	19.0	19.8	14.3	0.5
Feb	14.5	33.3	18.8	22.8	14.3	3.8
Mar	15.0	34.4	19.4	24.8	14.3	4.7
Apr	15.4	34.9	19.5	21.4	14.3	0.8
May	16.3	34.9	18.6		14.3	
Jun	14.0	37.6	23.6		14.3	

When the ethanol production margin is less than about 17 cents per litre some plants will not be covering their operating and capital costs, below 15 cents per litre most plants will not be covering their capital costs. When the ethanol production margin is less than 11–12 cents per litre most plants are not covering their operating costs and production begins to get shut down. This situation occurred most recently in 1996 when corn prices sky rocketed. The ethanol production margin would have to be above 17 cents per litre before most plants show a profit. This does not happen on a regular basis except in those States with producer incentives.

The gasoline blending margin must be positive for ethanol to be used as an extender and provide an incentive for the blender to use ethanol. When this margin is negative ethanol only becomes attractive for use as an octane enhancer or oxygenate. Some of the individual states that provide an incentive can have more favourable gasoline blending economics that is shown here since the wholesale price of ethanol in a given state will not reflect the full impact of the incentive because ethanol can be easily moved from an adjacent state without an incentive.

4. ALTERNATIVE FUELS TAXATION

In North America many alternative fuels receive different tax treatment than crude oil derived fuels. In both Canada and the United States transportation fuels are taxed by the Federal Governments, the Provincial or State Governments and in some cases by local authorities. In the following sections the taxation levels for conventional fuels and alternative fuels are documented.

In the United States the most important tax incentive is the Federal excise tax exemption for low level blends. It is generally high enough to equalize the cost of ethanol and gasoline. Some of the individual states have incentives for ethanol production or use but these are generally smaller than the federal incentive and they lead to high local levels of ethanol production or use.

In Canada it is the level of the combined Federal and Provincial incentives that is important. Individually they are not high enough to equalize the price of ethanol and gasoline.

The availability of tax incentives for biodiesel is very limited with only a couple of states offering financial incentives. These incentives still result in biodiesel being more expensive than diesel fuel.

4.1 CANADA - ETHANOL

The tax rates on transportation fuels in Canada are shown in Table 4-1. The data is in Canadian currency.

Table 4-1 Transportation Fuel Tax Rates in Canada

	Gasoline	Diesel	Methanol		Ethanol		Propane	Natural Gas
			M100	M85	E85	E10		
Federal Taxes	¢/L	¢/L	¢/L	¢/L	¢/L	¢/L	¢/L	¢/L
Federal Excise Tax	10.0	4.0	0.0	1.5	1.5	9.0	0.0	0.0
GST	7%	7%	7%	7%	7%	7%	7%	7%
Provincial Tax								
Newfoundland	16.5	16.5	16.5	16.5	16.5	16.5	7.0	n/a
PEI	13.0	13.5	n/a	n/a	n/a	n/a	12.0	n/a
Nova Scotia	13.5	15.4	13.5	13.5	13.5	13.5	7.0	n/a
New Brunswick[7]	10.7	13.7	n/a	n/a	n/a	n/a	6.7	n/a
Quebec	15.2	16.2	15.2	15.2	15.2	15.2	0.0	0.0
Ontario	14.7	14.3	0.0	2.2	2.2	13.2	4.3	0.0
Manitoba	11.5	10.9	11.5	11.5	9.0	9.0	5.7	7%
Saskatchewan	15.0	15.0	15.0	15.0	2.25	13.5	9.0	0.0
Alberta	9.0	9.0	0.0	1.4	1.4	8.1	6.5	0.0
BC	11.0	11.5	0.0	0.0	0.0	11.0	7%	0.0
Yukon	6.2	7.2	6.2	6.2	6.2	6.2	n/a	n/a
Northwest Terr	10.7	9.1	10.7	10.7	10.7	10.7	n/a	n/a

It can be seen from the table that ethanol along with methanol, propane and natural gas receive favourable tax treatment from the Federal Government. It must be noted that there is a multiplier effect of the different tax rates. The one cent per litre difference in tax between gasoline and a

[7] Alcohol blends are not legal in New Brunswick.

10% ethanol blend is one cent per 1/10th of a litre of ethanol so the ethanol tax incentive is equal to 10 cents per litre of ethanol. The ethanol must be produced from renewable resources to qualify for the exemption. This program has been in place since 1992.

Tax incentives for ethanol produced from renewable resources are in place in Ontario, Manitoba, Saskatchewan and Alberta. For the Manitoba incentive the ethanol must also be produced in Manitoba. The governments of Quebec and British Columbia have announced intentions to implement incentives when plants are operating in the Provinces. In the case of British Columbia the ethanol portion of the blend will be exempt from the Provincial tax of 11.0 cents per litre. In Quebec the incentive will be 130% of the gasoline tax rate or 19.76 cents per litre. In addition Ontario and Quebec have contracts between the ethanol producers and the governments that guarantee the level of the incentive for a period of time after the plant starts up subject to pricing levels of oil and feedstocks.

The Ontario, Saskatchewan and Alberta incentives exempt the ethanol from the Provincial tax and are thus applicable to blends of varying proportions. In Manitoba the ethanol blend must be at least 10% to qualify for the lower rate of tax. This effectively limits ethanol to either a 10% blend or E85. Blends with less than 10% ethanol receive no favourable tax treatment in Manitoba.

In Table 4-2 the effective financial incentives in each province are shown. This combines the Federal incentive with the Provincial incentive.

Table 4-2 Ethanol Tax Incentives by Province

	Effective Tax Incentive
	Cents (Can) per litre of ethanol
Newfoundland	10.0
PEI	10.0
Nova Scotia	10.0
New Brunswick[8]	-
Quebec	10.0[9]
Ontario	24.7
Manitoba	35.0
Saskatchewan	25.0
Alberta	19.0
BC	10.0[10]
Yukon	10.0
Northwest Territories	10.0

The Canadian incentives all apply to the use of ethanol. None of the Provinces currently offer any direct incentives for the production of ethanol. The ethanol incentives apply equally to ethanol made from biomass and ethanol made from cereal grains.

4.2 CANADA – BIODIESEL

Biodiesel receives no tax incentives from the Federal Government or any of the Provincial Governments in Canada. The concept of biodiesel receiving the same Federal tax incentive as

[8] Alcohol blends are not legal in New Brunswick.
[9] 34.96 cents per litre when a plant is operating in the Province. One company has plans for a 120 million litre per year plant underway.
[10] 21.0 cents per litre when a plant is operating in the province. There are no concrete plans at the moment.

ethanol has been considered at the bureaucratic level but no concrete proposals have ever been developed to make a cabinet submission to the politicians.

4.3 UNITED STATES - ETHANOL

Taxation of motor fuels in the United States is similar to Canada in that taxes are applied both by the Federal Government and by State Governments.

The most significant tax incentive in the United States is the federal incentive of 5.4 cents per gallon of 10% ethanol blended gasoline. The multiplier effect of the 5.4 cents applying to one tenth of a gallon of ethanol creates an effective tax incentive of 54 cents per gallon of ethanol or 14.3 cents per litre of ethanol. There are actually a number of programs and ways in which this incentive applies. The most common is the excise tax exemption which applies to three specific blends of ethanol and gasoline, 10% ethanol, 7.7% ethanol and 5.7% ethanol. The lower concentrations correspond to 2.7% and 2.0% wt oxygen respectively and are equivalent to the requirements under the oxygenated gasoline program and the reformulated gasoline program.

For the use of ethanol at other concentrations there is an alcohol fuels income tax credit of 54 cents per gallon of ethanol. While this is nominally the same as the excise tax incentive it is an income tax credit and only has value to the extent that the claimant has income tax payable and there will be some time delay between the time the ethanol is used and the time the income tax credit is realized. This credit could also be used for the manufacture of ETBE.

The tax rates on gasoline, diesel, propane and 10% ethanol blends are shown in Table 4-3. The source of the data for Tables 4-3 and 4-4 is Table MF-121T published by the Federal Highway Administration, Department of Transport. The data is believed to be accurate however other sources of information were found that were not totally consistent with this data. The reader is cautioned to confirm the data with the appropriate authorities before making any decisions based on the data.

Table 4-3 US Tax Rates on Motor Fuel – February 2000

State	Gasoline Rate		Diesel Rate		LPG Rate		10% Ethanol Rate		Ethanol Exemption	
	¢/gal	¢/L	¢/gal	¢/L	¢/gal	¢/L	¢/gal	¢/L	¢/gal	¢/L
Alabama	18	4.8	19	5.0	17	4.5	18	4.8	-	
Alaska	8	2.1	8	2.1	-	-	-	-	8[11]	2.1
Arizona	18	4.8	27	7.1	18	4.8	18	4.8	-	
Arkansas	19.5	5.2	20.5	5.4	16.5	4.4	18.6	4.9	-	
California	18	4.8	18	4.8	6	1.6	18	4.8	-	
Colorado	22	5.8	20.5	5.4	20.5	5.4	22	5.8	-	
Connecticut	32	8.5	18	4.8	-	-	31	8.2	1	.3
Delaware	23	6.1	22	5.8	22	5.8	23	6.1	-	
Dist. of Col.	20	5.3	20	5.3	20	5.3	20	5.3	-	
Florida	13.1	3.5	25.1	6.6	16.0	4.2	13.1	3.5	-	
Georgia	7.5	2.0	7.5	2.0	7.5	2.0	7.5	2.0	-	
Hawaii	16	4.2	16	4.2	11	2.9	16	4.2	-	
Idaho	25	6.6	25	6.6	18.1	4.8	22.5	6.0	2.5	.7
Illinois	19	5.0	21.5	5.7	19	5.0	19	5.0	-	
Indiana	15	4.0	16	4.2	-	-	15	4.0	-	
Iowa	20	5.3	22.5	6.0	20	5.3	19	5.0	1	.3

[11] Must be produced from biomass.

Kansas	20	5.3	22	5.8	19	5.0	20	5.3	-	
Kentucky	16.4	4.3	13.4	3.6	15	4.0	16.4	4.3	-	
Louisiana	20	5.3	20	5.3	16	4.2	20	5.3	-	
Maine	19	5.0	20	5.3	18	4.8	19	5.0	-	
Maryland	23.5	6.2	24.25	6.4	23.5	6.2	23.5	6.2	-	
Massachusetts	21	5.6	21	5.6	8.1	2.1	21	5.6	-	
Michigan	19	5.0	15	4.0	15	4.0	19	5.0	-	
Minnesota	20	5.3	20	5.3	15	4.0	20	5.3	-	
Mississippi	18.4	4.9	18.4	4.9	17	4.5	18.4	4.9	-	
Missouri	17	4.5	17	4.5	17	4.5	17	4.5	-	
Montana	27	7.1	27.75	7.3	-	-	27	7.1	-	
Nebraska	23.9	6.3	23.9	6.3	23.9	6.3	23.9	6.3	-	
Nevada	24.75	6.5	27.75	7.3	22	5.8	24.75	6.5	-	
New Hampshire	19.5	5.2	19.5	5.2	18	4.8	19.5	5.2	-	
New Jersey	10.5	2.8	13.5	3.6	5.25	1.4	10.5	2.8	-	
New Mexico	18.5	4.9	19.5	5.2	-	-	18.5	4.9	-	
New York	28.7	7.6	27.35	7.2	8	2.1	28.7	7.6	-	
North Carolina	22	5.8	22	5.8	22	5.8	22	5.8	-	
North Dakota	21	5.6	21	5.6	21	5.6	21	5.6	-	
Ohio	22	5.8	22	5.8	22	5.8	22	5.8	1[12]	.3
Oklahoma	17	4.5	14	3.7	17	4.5	17	4.5	-	
Oregon	24	6.3	24	6.3	24	6.3	24	6.3	-	
Pennsylvania	25.9	6.9	30.8	8.1	18.9	5.0	25.9	6.9	-	
Rhode Island	29	7.7	29	7.7	29	7.7	29	7.7	-	
South Carolina	16	4.2	16	4.2	16	4.2	16	4.2	-	
South Dakota	22	5.8	22	5.8	20	5.3	20	5.3	2	.5
Tennessee	20	5.3	17	4.5	14	3.7	20	5.3	-	
Texas	20	5.3	20	5.3	15	4.0	20	5.3	-	
Utah	24.5	6.5	24.5	6.5	24.5	6.5	24.5	6.5	-	
Vermont	20	5.3	17	4.5	-	-	20	5.3	-	
Virginia	17.5	4.6	16	4.2	10	2.6	17.5	4.6	-	
Washington	23	6.1	23	6.1	-	-	23	6.1	-	
West Virginia	25.35	6.7	25.35	6.7	25.35	6.7	25.35	6.7	-	
Wisconsin	25.4	6.7	25.4	6.7	25.4	6.7	25.4	6.7	-	
Wyoming	14	3.7	14	3.7	-	-	14	3.7	-	
Mean	19.966	5.3	20.149	5.3	14.948	4.0	19.679	5.2		
Weighted Avg.	19.067	5.0	19.725	5.2	13.94	3.7	19.777	5.2		
Federal Tax	**18.4**	**4.9**	**24.4**	**6.5**	**13.6**	**4.0**	**13.0**	**3.4**	**5.4**	**1.4**

In the past as many as 30 states offered tax incentives or exemptions for ethanol blended gasoline (Davis 1999). Most of these have expired or been repealed.

Several states also apply a state sales tax to fuels and that data is shown in Table 4-4. The sales tax information is provided to provide an indication of the total level of fuel taxation in the state as well as data that is specific to ethanol blends is highlighted in the table. Three states apply full or partial exemptions for ethanol blends for these sales taxes.

[12] Provides a 1 cent per gallon income tax credit.

Table 4-4 State Sales Taxes on Motor Fuels

State	Sales Tax Percent	Remarks
Alabama	4	Applies to fuel not taxable under volume tax laws.
Arizona	5	Applies to fuel not taxed under the motor-fuel or use-fuel taxes. Liquefied petroleum gas sold, used or stored in State is exempt.
Arkansas	4.5	Special fuel for municipal buses and gasoline are exempt.
California	6	Applies to sales price including Federal and State motor-fuel taxes.
Colorado	3	Applies to fuel not taxable under volume tax laws.
Connecticut	5	A Petroleum Products Gross Earnings tax is applied to many petroleum products, in addition to the per gallon taxes.
Dist. of Col.	5.75	Applies to fuel not taxable under volume tax laws.
Georgia	4	A 3-percent "second motor-fuel tax" and a 1-percent sales tax apply to sales price including Federal motor-fuel tax.
Hawaii	4	Applies to sales price excluding Federal and State motor-fuel taxes. **Alcohol fuels are exempt**.[13]
Idaho	5	Fuels subject to the motor fuel volume tax are exempt.
Illinois	6.25	Applies to sales price excluding Federal and State motor-fuel taxes. **For gasohol, only 70 percent of the price is subject to sales tax.**
Indiana	5	Applies to sales price excluding Federal and State motor-fuel taxes.
Iowa	5	Applies to fuel not taxable under fuel tax laws, including those fuels taxable, then subject to refund.
Kansas	4.9	Applies to fuels not taxable under the volume tax laws.
Kentucky	6	Applies to sales price, exclusive of Federal tax, of fuels not taxable under the volume tax laws.
Louisiana	4	Fuels subject to volume tax are exempt. **Gasohol is exempt if alcohol produced in State.**
Maine	6	Applies to motor fuel not taxed at the maximum rate for highway use under the volume tax laws.
Maryland	5	Applies to motor fuel not taxed under other Maryland laws.
Massachusetts	5	Applies to fuels not taxable under the volume tax laws.
Michigan	6	Applies to sales price including Federal volume tax except when used in a passenger vehicle with capacity of 10 or more for hire over regularly scheduled routes in State.
Minnesota	6	Applies to fuels not taxable under the volume tax laws.
Nebraska	5	Gasoline is exempt. Diesel and alternative fuels subject to the volume tax are exempt.
New Mexico	5	Applies to fuels not taxable under the volume tax laws. Ethanol blends deductible under the gasoline tax laws are exempt.
New York	4	Applies to sales price including Federal motor-fuel tax.
North Dakota	5	Applies to fuels not taxable under the volume tax laws.
Ohio	5	Applies to fuels not taxable under the volume tax laws.
Oklahoma	4.5	Applies to fuels not taxable under the volume tax laws.
Pennsylvania	6	Applies to fuels not taxable under the volume tax laws.
South Carolina	5	Applies to sales price of aviation gasoline only.
South Dakota	4	Applies to fuels not taxable under the volume tax laws.
Tennessee	6	Gasoline on which the volume tax has been paid and not refunded and

[13] Must be ethanol from biomass to qualify.

		motor fuel subject to the use fuel tax are exempt.
Texas	6.25	Applies to fuels not taxed or exempted under other laws.
Utah	4.875	Applies to fuels not taxable under the volume tax laws.
Washington	6.5	Applies fuels not taxable under the volume tax laws. Certain providers of public transportation of handicapped persons are exempt.
Wisconsin	5	Applies to fuels not taxable under the volume tax laws.
Wyoming	4	Applies to sales price of LPG. Gasoline and diesel subject to volume tax are exempt.

In addition to the eight states identified in the two previous tables that offer tax incentives for the use of ethanol some states offer incentive payments for the production of ethanol in that state. Table 4-5 identifies the state producer payment plans. The Wisconsin incentive is new for 2000.

Table 4-5 Ethanol Producer Incentives

State	Incentive		Conditions
	¢/gal	¢/L	
Minnesota	20	5.3	Up to 15 million gal/year/plant. For 10 years from plant start-up.
Kansas	7	1.9	$2.5 million annual cap. Sunset 2001
Missouri	20	5.3	Annual cap of $6 million. First 12.5 million gal get $0.20/gal, next 12.5 million gal get $0.05/gal. Maximum plant payment is $3.125 million per year. Maximum 5 years per plant. Program expires in 2007.
Montana	30	7.9	$6 million annual cap. $3 million max per company. In place until 2005.
Nebraska	20	5.3	Maximum of $5 million per facility per year for five years. Being phased out with a new program paying $0.075/gal for three years for up to 10 million gallons per plant per year.
North Dakota	40	10.6	Up to 750,000 gallons per facility. Ethanol must be sold in state.
South Dakota	20	5.3	Maximum of $1 million per year per facility. 10 year limit.
Wisconsin	20	5.3	Up to 15 million gal/year. Five year limit.
Wyoming	40	10.6	Issues credit to the ethanol producer to be redeemed by the fuel wholesaler after blending 10% ethanol.

Hawaii has introduced an investment tax credit for ethanol production facilities in the state. The tax credit will be refundable in the event that the taxpayer has insufficient tax liability. The tax credit will be 30% of each $1 million per 1 million gallons per capacity. The existing tax incentive for the sale of ethanol blends will be repealed in 2006. The new incentive appears to apply to ethanol produced from sugar and starch crops as well as biomass ethanol.

E85 is taxed at 9.25 cents per gallon rather than gasoline’s 18.4 cents per gallon in recognition of its lower energy content. E85 will qualify for the income tax credit.

The federal government offers small ethanol producers and income tax credit of 10 cents per gallon of qualifying ethanol. The producer must produce no more than 56.7 million litres year and the ethanol must be used as a motor fuel. Due to the specifics of the income tax regulations this credit is not applicable to some co-operatives. There are moves underway by some politicians to rectify this problem.

In 1997 the United States General Accounting office studied the effects of the Alcohol Fuels Tax Incentives (GAO 1997). In that report they provided a chronology of the legislation and events affecting ethanol fuel use. That data is shown in the following table. The events involving tax or other fiscal incentives are shown in bold.

Table 4-6 Legislation and Events Affecting Fuel Ethanol Use

Year	Legislation/Event	Ethanol summary
1967	Air Quality Act of 1967 (P.L. 90-148)	Regulated ambient air quality. Established emissions standards and a basic fuel and fuel additive registration program.
1970	U.S. production of crude oil peaked	Increased U.S. dependence on foreign sources of crude oil, primarily from OPEC.
	Clean Air Amendments of 1970 (P.L. 91-604)	Established the National Ambient Air Quality Standards and began regulating fuel additives for air pollution reduction. Section 211 gave EPA the authority to regulate fuel and fuel additives, which included the authority to control or prohibit the sale of any fuel or fuel additive that it determined would endanger the public health or welfare.
1973	1973 Arab Oil Embargo	Disrupted petroleum supply and escalated price. Was the beginning of consumer efforts to conserve energy and reduce petroleum consumption.
	Emergency Petroleum Allocation Act of 1973 (P.L. 93-159)	Established government controls on domestic petroleum price and supply, replacing market forces.
1974	Supplier-Purchaser Rule, Buy-Sell Program, and Crude Oil Entitlement Program	Below-market petroleum prices and allocated supplies caused lowered incentives for oil exploration and production, increased incentives to import oil, and greater domestic oil demand.
	Unleaded motor gasoline was introduced at gasoline stations	Began the transition to unleaded gasoline. Transition was enhanced by the compatibility of unleaded gasoline with the catalytic converter, which was developed to reduce tailpipe emissions.
1975	Energy Policy and Conservation Act of 1975 (P.L. 94-163)	Established the Strategic Petroleum Reserve to deter and mitigate effects of future oil supply disruptions.
1978	U.S. demand for petroleum peaked	Subsequent decline in demand contributed to lower oil imports.
	Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620)	Restricted construction of electric powerplants with petroleum or natural gas as their primary fuel.
	Energy Tax Act of 1978 (P.L. 95-618)	**Established a 4 cents per gallon (then the entire amount of the federal gasoline excise tax) exemption from excise taxes for motor fuels blended with biomass-derived alcohols (minimum of 10-percent alcohol).**
1978	Iranian Revolution	Declines in Iran's crude oil production began a series of OPEC price escalations between 1979 and 1981. A worldwide recession occurred and oil consumption was depressed.
1980	Energy Security Act of 1980 (P.L. 96-294)	Authorized funds for building alcohol fuel production plants.
	Crude Oil Windfall Profit Tax Act of 1980 (P.L. 96-223)	**Extended the 4-cent exemption for gasohol to December 1, 1992, and established a blender's tax credit of 40 cents per gallon of alcohol used in the production of gasoline/alcohol mixtures.**
	Omnibus Reconciliation Tax Act of 1980 (P.L. 96-499)	**Placed a tariff on imported ethyl alcohol to be used in the production of gasoline/alcohol mixtures.**
1981	Petroleum Price and Allocation Decontrol (E.O. 12287)	Reinstated market forces for petroleum prices. Domestic crude oil production was revitalized. Deregulation of oil prices and the development of futures markets reduced the economic cost of an oil price shock. During an oil market shock, producers had the incentive to bring forth additional energy supplies and consumers had an incentive to reduce energy consumption because prices could adjust quickly and completely to changing information about potential future oil supplies.
1982	**Surface Transportation Assistance Act of 1982 (P.L. 97-424)**	**Raised the gasoline tax rate from 4 to 9 cents per gallon and increased the exemption for gasohol from 4 to 5 cents per gallon. Set a 9 cents per gallon exemption for fuels containing 85 percent or more alcohol.**

1984	**Tax Reform Act of 1984 (P.L. 98-369)**	**Raised the exemption for gasohol from 5 to 6 cents per gallon. Increased the blender's tax credit from 40 to 60 cents per gallon of blend for 190-proof alcohol.**
1986	Price of crude oil collapsed	Domestic crude oil production declined, dependence on OPEC crude oil increased, and lower petroleum prices stimulated economic growth.
	Tax Reform Act of 1986 (P.L. 99-514)	**Reduced the exemption for 85-percent alcohol fuels from 9 to 6 cents per gallon.**
	Superfund Revenue Act of 1986 (P.L. 99-499)	Raised the gasoline excise tax rate from 9.0 to 9.1 cents per gallon.
1988	Alternative Motor Fuels Act of 1988 (P.L. 100-494)	Addressed national energy policy concerns and created a program of financial support for research, development, and demonstration of alternative motor vehicles and alternative fuels.
	Technical and Miscellaneous Revenue Act of 1988 (P.L. 100-647)	Permitted gasohol blenders to purchase gasoline and alcohol at different locations and still get the 6 cent per gallon exemption without having to file a claim for an excise tax refund.
1989	Reid Vapor Pressure Regulations	Reduced evaporative emissions of smog-producing compounds in gasoline.
1990	Persian Gulf Crisis of 1990-91	Unlike with previous oil supply disruptions, the impact from the sudden oil price increase and supply cutoff was reduced. Reduction was attributable to the deregulation of oil prices, to the development of futures markets, to the achievement of greater efficiency and fuel-switching capabilities by oil users, and to greater worldwide cooperation. Cooperation included the use of worldwide strategic reserves, an OPEC increase in production, and non-OPEC producer supply shifts.
	Omnibus Budget Reconciliation Act of 1990 (P.L. 101-508)	**Raised the gasoline excise tax rate from 9.1 to 14.1 cents per gallon, reduced the gasohol exemption from 6.0 to 5.4 cents per gallon, and reduced the blender's tax credit from 60 to 54 cents per gallon. Retained the exemption for 85-percent alcohol fuels at 6 cents per gallon. Extended these incentives to the year 2000. Provided an income tax credit of 10 cents per gallon for the first 15 million gallons of ethanol manufactured by qualified small producers with annual outputs of less than 30 million gallons.**
	Clean Air Act Amendments of 1990 (P.L. 101-549)	Initiated a mandated phaseout in the use of lead as a gasoline octane enhancer. Established the requirement that areas with the worst ground-level air pollution should use the following cleaner-burning motor fuels: oxygenated gasoline in carbon monoxide non-attainment areas during winter months and reformulated gasoline in ozone non-attainment areas. Reduced the sulfur content of diesel fuel.
1992	Energy Policy Act of 1992 (P.L. 102-486)	Extended gasohol excise tax exemption to blends containing less than 10-percent (7.7 and 5.7 percent) alcohol. To encourage the use of alternatives to petroleum-based transportation fuels, set guidelines and established incentives for (1) purchasing clean-fuel vehicles for federal, state, and private fleets and (2) arranging refueling facilities for these fleets.
	Oxygenated fuels program began	Required oxygenated gasoline use in wintertime in air quality non-attainment areas for carbon monoxide.
1993	Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66)	Raised gasoline excise tax rate from 14.1 to 18.4 cents per gallon.
1994	EPA mandated 30-percent minimum renewable oxygenate content for reformulated gasoline	Issued a ruling that at least 30 percent of each refinery's annual production of reformulated gasoline in 1996 and for each year thereafter should be derived from renewable oxygenates.
1995	Courts struck down 30-percent renewable oxygenate mandate	Struck down EPA's ruling of June 1994 mandating the use of at least 30-percent renewable alcohol in reformulated gasoline, which would have significantly expanded demand for ethanol.
	Reformulated gasoline program began	Required reformulated gasoline use in the worst air quality non-attainment areas for ozone.
1998	**Transportation Equity Act for the 21st Century**	**Ethanol excise tax exemption extended to 2007 with a slow phase down. (2001 &2002, 53 cpg; 2003 &2004, 52 cpg; 2005-2007, 51 cpg)**

4.4 UNITED STATES – BIODIESEL

The only tax incentives identified for biodiesel in the United States were a $0.21 per gallon of biodiesel excise tax exemption in Idaho, no tax in Arizona as a result of being classified as an alternative fuel and a 1 cent per gallon lower tax rate for fuels that meet EPAct requirements in Maryland. The primary source of information was the ATA Foundation Alternative Fuels Task Force Tax Guide for Alternative Fuels (ATA).

In most states biodiesel would be included in the definition of diesel fuel or a special fuel under the tax definitions and is therefore taxed as diesel fuel.

5. Other Financial and Market Incentives for Alternative Fuels

Governments can provide both financial assistance (other than direct tax relief) and market development assistance to initiatives that further government policy goals. Government goals that can be impacted by biofuels include a cleaner environment, increased energy security, increased employment, reduced government support for distressed sectors of the economy, increased trade etc.

Over the past twenty years many different programs have been used in North America to encourage and promote ethanol production and use. Many of these programs are no longer active. The focus of this chapter is to identify programs that are currently active and briefly describe any past programs that were very instrumental in the development of the industry.

Some states offer income tax credits for activities such as alternative fuelled vehicle purchases, advanced biofuels construction costs, energy from wood projects, and renewable energy systems. Other state programs include low interest loans for renewable energy projects and alternative energy bond fund programs. It is beyond the scope of this study to identify all of these incentive programs but a summary of the types of programs used by the states is provided.

5.1 Ethanol

The ethanol industry in North America has been very successful in engaging Governments in the development of the industry. There have been many programs introduced in both Canada and the United States. The existing programs and some of the key historical programs are identified in the following sections.

5.1.1 Canada

5.1.1.1 Research and Development Initiatives

The primary ethanol research and development initiative in Canada has been the Renewable Energy Technologies Program (RETP), managed by the CANMET Energy Technology Centre (CETC). RETP supports efforts by Canadian industry to develop and commercialize advanced renewable energy technologies that can serve as cost-effective and environmentally responsible alternatives to conventional energy generation. Technologies under development by RETP include active solar, wind energy, small hydro (less than 20 MW) and bioenergy.

RETP is working to advance promising renewable energy technologies to commercialization. The program is designed to enhance Canadian competitiveness by supporting the development of technologies that not only contribute to a cleaner environment and a broader industrial base, but also respond to international market demands.

The focus of the biofuels efforts within the RETP has been the conversion of plentiful and inexpensive cellulosic (woody) biomass to ethanol and value-added chemicals. Some of the projects supported have included pilot-scale projects such as Queen’s University’s extractive fermentation process and Tembec Inc.’s hemi-cellulose fermentation efforts. The intent is to demonstrate technology developed under the program and promote its transfer to the private sector. Support has also been given to Iogen Corporation of Ottawa to develop an integrated process for the production of fuel ethanol from cellulosic feedstocks such as wood waste.

The Canadian Forest Service of NRCan is investigating through its ENFOR program the process of developing and testing the technology for establishing willow-energy plantations. Fast-growing trees such as willow may make good feedstock for ethanol production.

R&D priorities are set in close consultation with industry in order to meet their needs. Most research falls within the short-to-medium term and is conducted through cost-shared agreements. Partners in R&D include a variety of stakeholders in the energy industry, such as manufacturers, developers, consultants, utilities, provincial governments and other federal departments. As a governmental organization, CETC's objectives are to secure environmental, economic and social benefits while fostering the wise use of conventional energy and the increased use of renewable energy and alternative fuels.

CETC undertakes no projects without partners. CETC works with industry and other private sector companies, with trade and professional associations, utilities, universities, and other levels of government. The level of effort on biofuels has been less than $1 million (Can) the past several years.

Between 1992 and 1996 Agriculture and Agri-Foods Canada undertook a national research initiative on ethanol evaluating the feasibility of using different agricultural products as a feedstock source. The intent was to reduce the production of greenhouse gases through the cycling of carbon. The initiative evaluated ethanol feedstocks (grains and lignocellulosics) available for agricultural sources and evaluates the by-products from ethanol production for the use as feeds or other industrial uses.

The program objectives were:

- to improve the economics and sustainability of supplying carbon in the form of ethanol by investigating biomass resource options, conversion process improvements, and coproduct development;
- to perform an economic, environmental, and energetic assessment (system assessment) of supplying ethanol.

The department now has a very modest program focussed on resource assessment for lignocellulosic feedstocks.

5.1.1.2 Development and Demonstration Initiatives

The Federal government's ethanol initiative to encourage the production and use of fuel ethanol was announced in November 1992. This initiative complemented the tax incentive in the 1992 federal budget to use ethanol as a transportation fuel. In December 1994, the government reiterated its support for the production and use of fuel ethanol by announcing the National Biomass Ethanol Program. This program introduced a $65-million, government- guaranteed line of credit that made it easier for manufacturers to obtain private sector financing for ethanol plants, and will provided a means of rescheduling their long-term debt in the event of financial difficulties should a future government change the excise tax on fuel ethanol. The program was administered by the Farm Credit Corporation on behalf of Agriculture and Agri-Food Canada. The program resulted in one large corn ethanol plant being constructed in Ontario. The program still provides support to the one plant but is closed to new applicants.

Technology Partnerships Canada (TPC) is a technology investment fund established to contribute to the achievement of Canada's objectives: increasing economic growth, creating jobs and wealth, and supporting sustainable development. TPC advances and supports government initiatives by investing strategically in research, development and innovation in order to encourage private sector investment, and so maintain and grow the technology base and technological capabilities of Canadian industry. TPC also encourages the development of small and medium-sized enterprises (SMEs) in all regions of Canada.

TPC supports research, development and innovation in:

- Environmental technologies

- Enabling technologies (advanced manufacturing and processing technologies, advanced materials processes and applications, applications of biotechnology, and applications of selected information technologies)
- Aerospace and Defence

TPC makes investments in projects that would not otherwise proceed within the desired scope, timing or location. All TPC projects undergo extensive evaluation to determine whether they meet the strategic objectives of the government, including technological and net economic benefits to Canada. TPC has supported the development of Iogen's cellulosic ethanol commercial demonstration plant currently underway in Ottawa.

5.1.1.3 Market Incentives

The Federal government has introduced green purchasing initiatives. These "best practices" are intended as guidelines, and are applied with existing policies, regulatory considerations, cost-effectiveness and technological feasibility considerations borne fully in mind. Over time, these best practices should continue to evolve and move progressively towards pollution prevention.

The key is a government procurement policy which;

- consistent with Canada's international trade obligations, purchases products and services that meet environmental specifications wherever these are available, and considers life-cycle costs. In some cases, this could involve a small price differential;
- provides green procurement training to officers with purchasing authority to improve decision-making, such as *Implementing Environmental Purchasing Policies* available from Environment Canada;

With respect to motor vehicle fleets the key guidelines with respect to biofuels are to:

- manage fleet vehicles in accordance with economic and environmental objectives of the *Treasury Board Motor Vehicle Policy* developed in partnership with Natural Resources Canada and Environment Canada;
- maximize fuel efficiency and the use of alternative fuels to conserve energy and reduce emissions;
- wherever possible, use low-sulphur diesel and ethanol-gasoline blends, meeting environmental specifications;
- perform emission testing and regular maintenance on vehicles to ensure maximum operating efficiency;
- recycle all used vehicle liquids (i.e., oil, anti-freeze, CFCs); and

The federal government also passed an act (Bill S-7) in 1995 this act was designed to accelerate the use of alternative fuels for motor vehicles. Key excerpts from the act are as follows;

It is the purpose of this Act that, for the fiscal year commencing on April 1, 2004 and for every fiscal year thereafter, where it is cost effective and operationally feasible, seventy-five per cent of motor vehicles operated by all federal bodies and Crown corporations will be motor vehicles operating on alternative fuels, thereby promoting the replacement of petroleum-based fuels for transportation.

The President of the Treasury Board shall take such measures as may be necessary to ensure that all federal bodies that acquire motor vehicles shall, where it is cost effective and operationally feasible to do so, in the aggregate, select, in percentages not less than those following, motor vehicles powered by engines that are capable of operating on alternative fuels;

- fifty per cent, for the fiscal year commencing April 1, 1997;

- sixty per cent, for the fiscal year commencing April 1, 1998;
- seventy-five per cent, for the fiscal year commencing April 1, 1999 and for every fiscal year thereafter.

Obligatory use

Where it is cost effective and operationally feasible to do so, a federal body shall use an alternative fuel in the operation of any motor vehicle capable of operating on such a fuel.

These two government policies have resulted in small increases in the use of ethanol-blended gasolines and E85.

There have not been any direct investments in biofuel production facilities by the federal government. One ethanol plant in Ontario did receive a small direct grant from the Province of Ontario for its production facility.

5.1.2 United States

In the United States both the US Department of Agriculture and the Department of Energy are involved with biofuels. Both departments perform and fund R&D and both are involved with other initiatives to accelerate the development of biofuels.

5.1.2.1 Research and Development Initiatives

The USDA and US DOE undertake research in ethanol processes and biodiesel development. The focus of the R&D in the different groups is different. The USDA is interested in feedstocks that are agricultural in origin and the DOE is involved in cellulosic ethanol. Given that cellulosic ethanol can be derived from agricultural residue there is some overlap between the programs and with the new Biobased Products and Bioenergy Initiative there is more co-ordination and co-operation between the two departments than there might have been in the past.

USDA BIOBASED PRODUCTS/BIOENERGY INITIATIVE

It is thought that increased investments in the development of biobased products and bioenergy will help to strengthen farm income, create new jobs in rural communities, broaden opportunities for rural businesses, enhance U.S. energy security by providing alternatives to foreign oil sources, and reduce air pollution and greenhouse gas emissions. The President has asked Federal agencies to report on activities to further the development and use of biobased products, with a goal to triple the U.S. use of biobased products and bioenergy by 2010.

The USDA budget proposes a total of $268 million, an increase of about $96 million (56 percent) above the 2000 level, to support research and development, demonstration and commercialization, and outreach and education activities. The increase is proposed to expand the research efforts of the Agricultural Research Service (ARS), the Co-operative State Research, Education, and Extension Service (CSREES) and the Forest Service (FS) to develop methods to transform biomass into energy and exchange technology transfer activities. Research will also be conducted to develop new biobased materials, such as lubricants, adhesives, and building materials; new crops for value-added products; increase knowledge of fundamental biomaterials science; and improve conversion of agricultural materials into biofuels.

In addition to research programs, increased funds will be used to initiate new programs for providing technical and financial assistance for producers of bioenergy or biobased products, including development of pilot crop insurance policies for growers of crops to be used for biobased products or bioenergy; business and industry loans for co-operatives processing or marketing biobased products; and grants for bioenergy community projects.

The Commodity Credit Corporation (CCC) will provide up to $100 million in 2000, and up to $150 million in 2001, in bioenergy incentive payments to encourage increased production of fuel grade ethanol and biodiesel from grain. The program details are still under development but indications are that manufacturers of ethanol and biodiesel with a production capacity of less than 113 million litres per year will receive one bushel of feedstock for ever 2.5 bushels used to expand production and larger producers will receive one bushel for every 3.5 bushels used for expanded production (OXY-FUEL NEWS). The commodities eligible under the program include corn, barley, sorghum, oats, rice, wheat, soybeans, sunflower seed, canola, crambe, rapeseed, safflower and flaxseed.

The breakdown of the USDA 2000 and proposed 2001 budget is shown in Table 5-1.

Table 5-1 USDA Budget for Biobased Products / Bioenergy Initiative

	2000 Current Estimate	2001 Budget
	Millions $	Millions $
Agricultural Research Service (ARS)	46	63
Commodity Credit Corporation	100	150
Co-op State Research, Education and Extension	11	19
Forest Service	9	19
Natural Resource Conservation Service	5	9
Chief Economist	1	2
Rural Development	0	4
Risk Management	0	1
Administration Offices	-	-
Office of Secretary	0	1
Total	172	268

USDA CLIMATE CHANGE TECHNOLOGY INITIATIVE

The budget proposes $24 million to support the President's Climate Change Technology Initiative (CCTI) to develop and demonstrate technologies that reduce greenhouse gas emissions from agriculture and forestry and examine strategies to adapting to climate change. Within the total, $14 million will support ARS and FS work on converting biomass to energy, which plays a pivotal role in the Bioproducts/Bioenergy Initiative to expand opportunities for rural communities, reduce U.S. dependence on foreign oil sources, and provide a cleaner alternative energy source. Of the $14 million, FS will provide $9.5 million for research on small diameter and short-rotation trees and ARS will devote $4.5 million in program increases focused on biomass conversion technologies.

THE US DEPARTMENT OF ENERGY

The mission of the DOE Biofuels Energy System–Transportation program, managed by the Office of Energy Efficiency and Renewable Energy's Office of Transportation Technologies, is to research, develop, and demonstrate cost competitive technologies for the production of liquid transportation fuels, in collaboration and partnership with industry, other government organizations, academic institutions, and others. In support of this mission, the program pursues the development of low-cost biomass energy feedstocks and cost competitive, highly efficient conversion technologies for liquid fuels production from cellulosic methods. Biomass feedstocks include agricultural residues (e.g., rice straw/husks, bagasse), forest wastes/residues, (e.g., sawdust, thinnings), and energy crops, i.e., trees and grasses grown specifically for use as energy feedstocks. Based on its near-term potential, the program focuses on the production of ethanol.

For the ethanol program, production cost goals have been established. The goals provide the direction for the research and development activities supported by the program. By the year 2000, the goal is to demonstrate technologies, in partnership with industry, that are capable of producing ethanol at a cost of $1.13 per gallon (1996 dollars). This goal applies to green field facilities, although most of the demonstration projects currently under consideration are retrofits of existing facilities or add-ons to biomass power facilities, which significantly lowers the capital investment costs and results in an estimated ethanol production cost of $0.70 to $0.90. Currently, three highly leveraged partnerships to build ethanol demonstration facilities have been established. Each of these facilities is being financed with an 80 percent or higher private sector investment and a 20 percent or less DOE cost share. Additional partnerships will be established that will ultimately lead to the design and construction of cellulose-to-ethanol facilities. By the year 2004, at least three ethanol facilities will be in operation using biomass wastes, and a partnership with the corn ethanol industry will complete pilot-scale testing on ethanol production from corn stover.

Also in partnership with industry, the goal by the year 2005 is to demonstrate technologies capable of economically producing ethanol from energy crops, such as switchgrass. Under Biofuels Energy Systems the intent is to develop and demonstrate technologies capable of producing ethanol at a cost of $0.72 per gallon by the year 2010. To accomplish the program's cost goals and proceed beyond the first demonstration facilities, research, development and demonstration activities are conducted in accordance with integrated biomass feedstock and conversion systems. Energy cropping systems using the best varieties and management practices must be developed through breeding and reliable field testing in the different growing regions in the United States across a wide range of sites and conditions.

Specific areas within the ethanol conversion process have been identified which offer the most significant opportunities for efficiency improvements and cost reductions. These areas include improvements in enzyme production and efficiency (so that less enzyme is needed), pretreatment methods that prepare the biomass for conversion to ethanol, and fermentation organisms to convert the range of sugars that can be found in the differing types of biomass materials. The program will also evaluate potential cost reductions based on possible co-products, including electricity and industrial chemicals.

Biomass/Biofuels Energy Systems-Transportation and Biomass/Biofuels Energy Systems-Power Systems are conducting analyses of biomass resource availability in a co-ordinated fashion. Most of the research and development activities for feedstock and conversion improvements are conducted through the Department's national laboratories, using in-house capabilities, subcontracted researchers and facilities at universities, other government agencies such as the United States Department of Agriculture, and industrial scientists with the best expertise and experience.

The Regional Biomass Energy Program (RBEP), funded as a part of this Biofuels Energy Systems-Transportation program plays a significant role in technology deployment. RBEP, through its local and regional contacts, transfers current and reliable information on biomass development activities to potential users. This includes economic and technical information, as well as State and local regulatory, environmental, and market considerations for the production of fuels, chemicals, and electricity. Existing organizations, such as the Coalition of Northeastern Governors, Council of Great Lakes Governors, the DOE Atlanta Regional Support Office, the DOE Seattle Regional Support Office, and the DOE Denver Regional Support Office, serve as RBEP hosts and contacts for their respective regions in the United States.

The performance objectives for the current fiscal year are;

- Establish economic feasibility of enzymatic conversion of cellulose to ethanol (on site *Trichoderma reesei* production) at the bench scale.
- Select partner to demonstrate enzymatic conversion of cellulose to ethanol as an add-on to corn-to-ethanol facility.
- Establish partnership with equipment manufacturers and other groups for R&D of harvesting, handling, and storage alternatives for switchgrass.

- Ethanol production cost competitive in the oxygenate market for acid hydrolysis plants with shared infrastructure (e.g., colocated with biomass power plants) and with access to biomass feedstocks at less than $5 per dry ton.

The performance objectives for the period 2001 to 2006 are;

- Select enzyme manufacturing partner to develop advanced cellulase enzyme system. (2001)
- In partnership with USDA, complete development of integrated equilibrium economics model for energy crops. (2002)
- Ethanol production cost competitive in the oxygenate market for acid hydrolysis plants with shared infrastructure (e.g., colocated with biomass power plants) and with access to biomass feedstocks at less than $10 per dry ton. (2003)
- Demonstrate 3-fold improvement (from 1998 base) of cellulase enzyme activity. (2004)
- Ethanol production cost competitive in the oxygenate market for enzyme hydrolysis plants with shared infrastructure (e.g., colocated with biomass power plants or corn ethanol plants) and with access to biomass feedstocks at less than $15 per dry ton. (2006)
- Begin development of enzymatic conversion technologies with appropriate industry partners. (2002)
- In partnership with USDA, complete development of integrated equilibrium economics model for energy crops. (2002)
- Begin commercial demonstration of softwoods to ethanol and electricity. (2003)
- Complete pilot testing of countercurrent pretreatment reactor with industry. (2003)
- Demonstrate 3-fold improvement (from 1998 base) of cellulase enzyme activity. (2004)
- Conduct pilot testing with ethanol partner for energy crop conversion. (2004)
- Begin small commercial scale demonstration of enzymatic process in collaboration with a corn-ethanol producer. (2005)
- Demonstrate first-of-a-kind switchgrass conversion to ethanol at a production plant. (2005)
- Demonstrate improved enzymatic hydrolysis technology at the pilot scale. (2006)

The US DOE Biofuels budget for the period 1998 to 2000 is shown in Table 5-2.

Table 5-2 US DOE Biofuels R&D Budget

	FY 1998	FY 1999	FY 2000	$ Change	% Change
	(dollars in thousands)	(dollars in thousands)	(dollars in thousands)	(dollars in thousands)	
Ethanol Production	25,027	35,950	37,441	1,491	4.1%
Biodiesel Production	800	750	1,000	250	33.3%
Feedstock Production	2,500	2,800	5,500	2,700	96.4%
Regional Biomass Energy Program	2,000	2,250	3,500	1,250	55.6%
Integrated Bioenergy Research and Development	0	0	6,000	6,000	>999 %
Total, Biomass/Biofuels Energy Systems -Transportation	30,327	41,750	53,441	11,691	28.0%

5.1.2.2 Development and Demonstration Initiatives

Within the DOE budget there is considerable money for the establishment of demonstration facilities for cellulosic ethanol plants. As described above the DOE contributions are highly leveraged when the total cost of the project is considered.

The USDA Rural Business- Co-operative Service has a loan guarantee program that has been used for some ethanol plants recently. The objective of the program is to improve the economic and environmental climate in rural communities. The guarantees are designed to reduce risk, and assist with leverage for a project. The guarantees will cover up to 60% for a $25 million loan. In recent years $800 to $1000 million dollars has been appropriated for the program. A portion of the program (about 25%) has been set aside specifically for co-operatives. Obviously not all of this is for ethanol plants.

This program has been accessed by a number of the co-operative ethanol plants that have been built in Minnesota over the past several years. The recent history of the program has been good with a low loss rate on the part of the program. Loan guarantees were also offered in the early 1980's for several large ethanol plants. Some of these plants had significant operating problems and the cost to the US government was $80,000,000 to cover the loan guarantees.

The USDA Rural Business- Co-operative Service has a number of smaller programs, some of which may be available to provide grants for developing new enterprises.

5.1.2.3 Market Incentives

The United States is a very significant importer of energy with over 60% of the crude oil required for the US economy currently being imported. In the past, oil supply disruptions have had a significant negative impact on the US economy and as a result energy security has always been high on the agenda of the US DOE. Numerous laws and policies have been implemented, including encouraging the use of mass transit and high-occupancy vehicles (e.g., carpooling), improving auto efficiency, and developing alternative fuels-either by themselves or as a blend with gasoline.

FEDERAL MARKET INCENTIVES

In 1992, Congress passed the Energy Policy Act (the act) with the objective, among others, of reducing petroleum use in transportation by encouraging the use of alternative fuels in light-duty vehicles (cars and light trucks). Alternative fuels include ethanol, methanol, natural gas, propane, electricity, and biodiesel, among others. Alternative fuel vehicles operate on these fuels, although some of them can also consume gasoline. The act established goals of having alternative fuels replace at least 10 percent of the petroleum fuels projected to be consumed in 2000 and at least 30 percent of projected consumption in 2010. To help reach these goals, it also mandated that a portion of the new vehicles acquired for fleets operated by federal agencies, state governments, and alternative fuel providers[14] must be alternative fuel vehicles. DOE was tasked with a number of responsibilities related to these activities, including monitoring the progress towards the fuel replacement goals and collecting data to measure compliance with the act's fleet mandates.

Since the passage of the Energy Policy Act of 1992, some, albeit limited, progress has been made in acquiring alternative fuel vehicles and reducing the consumption of petroleum fuels in transportation. DOE estimates about 1 million alternative fuel vehicles were on the road in 1999, about 0.4 percent of all vehicles. It also estimates that, in 1998, alternative fuels used in alternative fuel vehicles replaced about 334 million gallons of gasoline, which represents about 0.3 percent of the total gasoline consumed during that year. In addition, about 3.9 billion gallons of alternative fuels (e.g., ethanol and methanol) were blended with gasoline[15] and used in conventional vehicles in 1998. Thus, in total, about 4.23 billion gallons of gasoline were replaced

[14] Alternative fuel providers, as defined by the act, are businesses that are involved in (1) producing, refining, storing, processing, transporting, distributing, importing, or selling at the wholesale or retail level alternative fuels other than electricity; (2) generating, transmitting, importing, or selling wholesale or retail electricity; or (3) producing or importing an average of 50,000 barrels per day of petroleum.

[15] This blend is known as oxygenated gasoline, which consists primarily of gasoline with small additional quantities of oxygenated compounds derived from ethanol or methanol. The act recognizes these compounds as counting towards the fuel replacement goals. This fuel is currently available in a number of states.

by alternative fuels or approximately 3.6 percent of all highway gasoline use, considerably less than the act's goal of 10 percent in 2000.

While the goals of EPAct have not been met the program has encouraged the development and purchase of E85 flexible fueled vehicles by a number of government agencies. With the large number of these flexible fuel vehicles on the road there is growing interest in supplying the fuel for the vehicles particularly in the mid west. The growing demand for E85 identified in Table 2-4 is in part due to EPAct.

The specific purchase requirements of the act are shown in Table 5-3.

Table 5-3 EPAct Vehicle Acquisition Mandates

	Percentage of all Acquisitions for Mandated Groups		
Year	Federal Agencies	State Governments	Alternative Fuel Providers
1996	25	N/A	N/A
1997	33	10	30
1998	50	15	50
1999	75	25	70
2000	75	50	90
2001 and beyond	75	75	90

Automobile manufacturers in the United States are required to meet Corporate Average Fuel Economy (CAFÉ) standards each year. Failure to meet the standards results in fines for each vehicle sold. Alternative fuels receive a significant fuel economy bonus under the regulations. The exact magnitude of the credit is dependent on each manufacturer's fleet but to a manufacturer who is in the position of having to pay a CAFE fine the credits can be used to reduce or eliminate the fine. In the case of E85 the credit is worth up to $1100 per vehicle, which is higher than the incremental cost of producing the E85 car, and acts as an incentive to produce E85 vehicles. The three major auto manufacturers in the US all produce E85 vehicles.

The Clean Cities is a program sponsored by the U.S Department of Energy which is designed to encourage the use of alternative fuel vehicles (AFVs) and their supporting infrastructure throughout the nation. By encouraging AFV use, the Clean Cities program is designed to help achieve energy security and environmental quality goals at both the national and local levels. The Clean Cities program takes a unique, voluntary approach to AFV development, working with coalitions of local stakeholders to help develop the AFV industry and integrate this development into larger planning processes.

The Clean Cities program uses a flexible approach to the challenge of building alternative fuels markets, providing participants with options to address problems unique to their cities, and fostering partnerships as the mechanism to overcome these problems. Clean Cities works directly with local businesses and governments, guiding them through each step in the process of building the foundation for a strong local organization, including goal-setting, coalition-building, and securing commitments. Clean Cities is dedicated to:

- Creating new jobs and commercial opportunities
- Facilitating alternative fuel vehicle production and conversion
- Expanding local refuelling infrastructure
- Developing "Clean Corridors"
- Increasing public awareness
- Advancing clean air objectives
- Supporting regulated fleets

Some of the Clean Cities groups are actively working on E85 programs and on biodiesel initiatives.

STATE INCENTIVES

At the state level a number of states including Illinois, Iowa, Kansas, Montana, Wisconsin, Wyoming, South Dakota and Idaho have regulations requiring state vehicles to be operated on ethanol blended gasoline. The states of Iowa, Missouri and Nebraska have state offices or organizations whose mandate is to promote the production and use of ethanol.

Many states are supportive of alternative fuels and alternative fuelled vehicles (AFV). The National Conference of State Legislatures recently addressed alternative fuel incentives and attempted to determine what worked and what didn't work to accelerate the implementation of AFV's (Alternative Fuel News). A summary of the findings is presented below. These incentives are not specific to biofuels but cover all alternative fuels.

Grants

- 18 states offer grants
- Grants are the most commonly used and most desired form of incentive
- Most are available to both public and private entities
- Consumers are confident that they will receive grant funds at the time of purchase.

Tax Incentives

- 21 states offer tax incentives
- Not as popular as grants
- Tax incentives do not help municipalities, state governments, and municipal utilities but these fleets represent a majority of the AFV population
- Tax deductions are of limited use to small business fleets with low net income.

Fuel Price/Tax Deductions

- 33 states offer fuel price/ tax and sales tax discounts or exemptions
- Fuel price discount encourage fuel use rather than vehicle purchases
- Tax reductions for fuel have a long payback period and do not result in enough of a price discount to attract a new market.

Loans

- 29 states offer loans; 16 are specific to ethanol and E85
- loans are powerful but can be less effective than tax deductions and credits
- Loan programs are more effective if they have dedicated personnel to manage them
- Loans are more useful to fleets in areas with high price differentials between alternative fuel and gasoline or diesel to make the economics attractive.

Non-Financial Incentives

- Many states include high occupancy vehicle (HOV) lane access and preferential parking
- Five states allow HOV lane access to AFV with less than the required occupants
- Non-financial incentives can be particularly attractive to private fleets, but often require additional vehicle identification, such as decals or special license plates.

5.2 BIODIESEL

5.2.1 Canada

There are no programs in Canada that are specifically designed to assist with biodiesel production or use. There has been a small amount of Federal research money used for biodiesel R&D under general bioenergy programs but it has not been the focus for any of the programs.

5.2.2 United States

The Biofuels Energy Systems-Transportation program is also exploring opportunities to produce renewable fuels for heavy vehicle use by supporting biodiesel production activities. These activities include research to lower the costs of biodiesel and the testing and development of new fuel formulations for heavy vehicle use. Niche opportunities for biodiesel are available in environmentally sensitive areas, such as underground mining, marine, and fragile ecosystems (e.g., National Parks). Diethyl ether (DEE) made from ethanol is a fuel that will also be evaluated for its application to heavy vehicle use. DEE's high cetane number and other fuel properties make it particularly attractive for heavy vehicle application.

Biodiesel facilities would also be eligible for the USDA loan guarantee programs.

The biodiesel industry is attempting to take full advantage of EPAct. They have been successful in obtaining alternative fuel status for B20 in the United States and have the purchase of B20 count towards a mandated groups purchase requirement of alternative fuel vehicles. There is also some discussion with automakers to identify certain vehicles as biodiesel fuelled that would make compliance with the act easier. The lack of alternative fuel heavy-duty vehicles available from the automakers results in a unique market niche for biodiesel. The additional cost of the fuel does not appear to be a significant market barrier at this time for this market segment as the full life cycle cost of alternatives such as natural gas heavy duty vehicles can be higher.

In Arizona, B20 has been identified as a clean burning fuel that makes it eligible for inclusion in the state mandated alternative fuel program. This program is similar to EPAct in that it requires vehicle purchased for the state fleet to be alternative fuelled vehicles or fuelled by cleaner burning fuels. The lack of alternative fuel heavy-duty vehicles provides a unique market niche for B20 fuels.

The state of Indiana offers a 10% price premium in their procurement procedures for the purchase of biodiesel for use in state vehicles, Delaware, Iowa and Ohio have endorsed the use of biodiesel in state vehicles.

6. ENVIRONMENTAL POLICY

Environmental policies and programs can have a significant impact on the development of reformulated or alternative fuels. Issues such as poor local air quality and health impacts caused by high levels of criteria air contaminants are driving significant changes in fuel composition and quality throughout North America. Emerging issues such as climate change and the ratification of the Kyoto Protocol by governments throughout the world are likely to have the same kind of impact on fuel composition and fuel consumption in the coming decades that local air quality issues have had in the past two decades.

Ethanol and biodiesel can be used to reduce the impact of transportation fuels on the environment. The fuels can reduce emissions of criteria air contaminants as reduce life-cycle emissions of greenhouse gases. The magnitude of environmental impacts attributable to biofuels has been extensively studied and is well understood in North America. These issues are described further below.

In the United States two environmental programs, the Oxy-Fuel program and the Reformulated Gasoline program have contributed significantly to the demand for ethanol. There are no environmental program drivers for ethanol in Canada or for biodiesel in either country.

6.1 ETHANOL

The use of ethanol as a gasoline blending component will lower exhaust emissions of carbon monoxide, unburned hydrocarbons (including some hazardous and toxic air contaminants). There will be small increases in exhaust nitrogen oxides, increases in aldehyde emissions, as well as the potential for increases in evaporative emissions if the vapour pressure of the blend is not controlled. The magnitude of the changes in emissions is a function of the fuel engine system with the trend of more controlled engines having a lower impact from ethanol blended gasoline. The impact of 10% ethanol on emissions of carbon monoxide and hydrocarbons is shown in Table 6-1 ($(S\&T)^2$, 1999).

Table 6-1 Emission Impact from 10% Ethanol Blends

Emitter classification	Vehicle Technology	Impact at 10% Ethanol on HC Emissions	Impact at 10% Ethanol on CO Emissions
Normal Emitting Vehicles	LEV and Advanced Technology (1999+)	-14.0	Insufficient data
	Tier 1 (1994-1999)	-14.0	-10.9
	Tier 0	-10.3 to –21.5	-10.9 to –32.9
	Non-catalyst	-23.1	-23.1
High Emitting Vehicles	LEV and Advanced Technology (1999+)	No data	-18.6
	Tier 1 (1994-1999)	-20.3	-18.6
	Tier 0	-23.1	-18.6

The emissions from automobiles are a major source of air pollution in North American cities and greenhouse gas emissions from the transportation sector are significant. In Table 6-2 the contribution of vehicle emissions to these problems is shown.

Table 6-2 Contribution of Transportation to Air Emissions

	United States	Canada
	% of total emissions	% of total emissions
Greenhouse Gases	26.1	27.2
Carbon Monoxide	76.6	28
Volatile Organic Carbon	39.9	57
Nitrogen Oxides	49.2	67

The emissions from vehicles have been decreasing as new vehicles with better emissions control technology have been introduced. The emissions from older vehicles are still significant and the ability to reformulate the fuel to have an immediate impact on the emissions from all vehicles has been used in both Canada and the United States as an air quality improvement initiative. This section of the report considers the regulatory initiatives that have impacted ethanol demand in North America.

The use of ethanol blended gasoline will also reduce greenhouse gas emissions. The magnitude of the emission reduction is dependent on the farming and ethanol manufacturing practices. There are some differences between Canada and the United States with respect to these practices and recent studies (Levelton, 1999b and Wang, 1999) have documented the reductions in each country. The following table presents the highlights from each study. The use of coal in US ethanol plants and natural gas in Canadian plants is the most significant reason for the differences between the countries.

Table 6-3 Greenhouse Gas Emissions from Ethanol Fuels

	United States	Canada
	% reduction compared to gasoline	% reduction compared to gasoline
10% ethanol	0.8 –1.6	3.9 - 4.6
85% ethanol	13.7 –18.8	37.1 – 44.5

6.1.1 Canada

In Canada, gasoline quality is regulated by the provincial governments except for issues impacting directly on human health, which are a federal government responsibility. A few provinces have introduced regulations governing gasoline quality but none have mandated an oxygen level in gasoline or an ethanol requirement. Refiners have been able to meet the regulations through refinery modifications and changes in gasoline blending practices. The Federal government has moved to limit the benzene and sulphur contents of gasoline. The benzene level is now limited to 1.0 % Vol. and the sulphur level will be reduced to 30 ppm by 2005. Again there is no mandatory requirement for oxygen or ethanol to be added to gasoline.

Two regions of the country, the Lower Fraser Valley in BC and the southern Ontario region have introduced mandatory vehicle emission testing. Marketers of ethanol gasoline blends in these regions have experienced some increase in sales, as the public becomes aware of the potential for oxygenated gasolines to assist in passing the emission tests.

Canada has spent considerable effort over the past several years in studying the potential actions that could be undertaken to meet Canada's commitments under the Kyoto Protocol. To respond to this international GHG emissions target, Canada's first ministers directed federal, provincial and territorial ministers of energy and environment to put in place a national process to examine the impacts, costs and benefits of the Protocol's implementation and the various implementation options open to Canada.

Central to this engagement process was the creation of 16 Issue Tables/Groups consisting of 450 experts from government, industry, academia and non-governmental organizations. These national advisory groups are now completing their work, and their reports will form valuable input into the development of Canada's national implementation strategy.

Starting in July 1998, the Issue Tables/Groups undertook work on foundation papers. The purpose of the foundation papers was to analyse the current status of the Tables' respective sector/issue, including challenges and opportunities.

Building on this foundation work, members of the Issue Tables/Groups began sector-specific and cross-cutting analyses of opportunities and barriers to addressing climate change, and identifying options for consideration in the development of Canada's national strategy on climate change. The papers set out emissions reduction potential, major risks or barriers, implementation time frames, competitiveness implications and anticipated social, economic, environmental and health costs/benefits.

Ethanol gasoline blended gasoline has been identified as a “promising measure”. These measures have low to moderate costs ($10 to $100 per tonne of GHG) when measured against gasoline derived from crude oil at $18/bbl US. The measures have not been reconsidered with the higher oil prices being experienced today.

Canada intends to have the strategy and plan developed, in partnership with the provinces and territories and through stakeholder input, for late 2000 or early 2001. Some of the details ultimately contained in the Canadian approach will depend on the outcome of the 6th Conference of the Parties to the United Nations Framework Convention on Climate Change (CoP 6), to be held in The Hague in November 2000. In particular, CoP 6 is expected to refine the definition and rules pertaining to carbon sinks and to the "Kyoto Instruments," such as Emissions Trading, Clean Development Mechanisms and Joint Implementation, which may have a fundamental bearing upon Canada's national approach.

In addition to the efforts to develop a strategy and plan the federal government has made an annual investment of approximately $200 million that has been allocated to research, technology development and deployment, energy-efficiency programs and public education. A portion of this money has been used for the Iogen cellulosic ethanol demonstration plant in Ottawa. Beyond the $200 million annually in program expenditures, changes have been made in the federal tax system to support efforts in climate change, renewable energy and energy conservation. The government also links the favourable tax treatment it provides for the use of alternative transportation fuels such as propane and natural gas, as well as ethanol from biomass to its climate change initiatives.

6.1.2 United States

The Clean Air Act of 1970 set a national goal of clean and healthy air for all. It established the first specific responsibilities for government and private industry to reduce emissions from vehicles, factories, and other pollution sources. Today's cars typically emit 70 to 90 percent less pollution over their lifetimes than their 1970 counterparts.

Despite considerable progress, the overall goal of clean and healthy air continued to elude much of the country. Unhealthy air pollution levels still plagued virtually every major city in the United States. This is largely because development and urban sprawl have contributed to a doubling of vehicle travel since 1970. With these issues in mind, Congress and the Administration in 1990 amended and updated the Clean Air Act. The 1990 Clean Air Act included provisions to further control ground-level ozone (urban smog), carbon monoxide, and particulate emissions from diesel engines and to address air toxics and acid rain. Motor vehicles contribute to all these problems.

The new Clean Air Act strengthened components of the earlier law. The tailpipe standards for cars, buses, and trucks were tightened, and Inspection and Maintenance (I/M) programs were expanded to include more areas and allow for more stringent tests.

The 1990 law also introduces several entirely new concepts with regard to reducing motor vehicle-related air pollution. For the first time, fuel was considered along with vehicle technology as a potential source of emission reductions. The act mandated that improved gasoline formulations be sold in some polluted cities to reduce emissions of carbon monoxide or ozone-forming hydrocarbons.

A number of areas of the United States experience air quality that does not meet the US national standards. Areas that fail to meet the air quality objectives for carbon monoxide and for ozone are required to implement either oxygenated gasoline programs or reformulated gasoline programs.

The requirement to oxygenate the gasoline in the CO non-attainment areas was effective for the winter of 1992. The program, called the oxygenated gasoline program, has evolved over time with many of the original areas coming into compliance over time and dropping out of the program. Over time there has also been a shift from the use of MTBE to the use of ethanol to meet the requirements of the program. The current carbon monoxide non-attainment areas are shown in Table 6-4 along with the effective dates, the type of oxygenate used and comments. The source of the data was Table of Winter Oxygenated Fuels Programs by State, http://www.epa.gov/otaq/regs/fuels/oxy-area.wpd. This program has been very effective at creating demand for ethanol in the United States.

Table 6-4 Oxy-Fuel Areas of the United States

Area	Control Period/ Oxygen Content	Type	Comments
El Paso, Texas	10/1 - 3/31 2.7%	100% Ethanol	Continues to implement oxy program. TNRCC expanded the federal control period to begin Oct. 1 and end on March 31.
Denver/ Boulder, Colorado	11/1 – 2/7 AVG 3.1%	100% Ethanol	Final redesignation to CO “serious” non-attainment area was published in the FR on 3-10-97 (62 FR 10690-10700).
Ft. Collins, Colorado	11/1 – 2/7 AVG 3.1%	100% Ethanol	Working on redesignation request. Tentatively scheduled to be submitted to EPA by mid-summer 2000.
Missoula, Montana	11/1 - 2/29 2.7%	100% Ethanol	Voluntary ethanol only. Will continue to implement program.
Ogden, Utah	11/1 - 2/29		Not implementing oxy program. Ogden submitted a redesignation request. The Region is working on the request.
Provo/Orem, Utah	11/1 - 2/29 AVG 3.1%	100% Ethanol	Continues to implement program. State attempted to shorten program by two weeks, however, analysis indicated that this area is not a candidate for shortening of the oxyfuel season. Provo had a probability of an exceedance greater than 70% if oxyfuel was discontinued in the period considered.
Las Vegas, Nevada	10/1 - 3/31 3.5%	100% Ethanol	EPA audited in '94 Final redesignation to CO “serious” non-attainment area was published in the FR on 10-2-97 (62 FR 51604-51606).

Phoenix, Arizona	11/15 - 3/31 3.5%	100% Ethanol	EPA audited Dec. '94 Final redesignation to CO "serious" non-attainment area was published in the FR on 7-29-96 (61 FR 39343-39347).
Los Angeles, California	10/1 - 2/29 1.8 to 2.2%	100% MTBE	Classified as a "serious" CO non-attainment area.
Reno, Nevada	10/1 - 1/31 2.7%	100% Ethanol	EPA audited in Jan. '94. Has data to redesignate – working on redesignation request.
Grants Pass, Oregon	11/1 - 2/29 2.7%	100% Ethanol	Has data to redesignate – working on redesignation request. State plans to submit a redesignation request to EPA by Dec. 99 -- state is unsure as to whether or not the oxy program will continue to be implemented as a control measure.
Klamath Co., Oregon	11/1 - 2/29 2.7%	100% Ethanol	Has data to redesignate – working on redesignation request. State plans to submit a redesignation request to EPA by Dec. 99 -- state is unsure as to whether or not the oxy program will continue to be implemented as a control measure.
Medford, Oregon	11/1 - 2/29 2.7%	100% Ethanol	Has data to redesignate – working on redesignation request. State has submitted a redesignation request to EPA -- EPA is working on request.
Fairbanks, Alaska	11/1 - 2/29		Final redesignation to CO "serious" non-attainment area was published in the FR on 2-27-98 (63 FR 9945-9948). EPA is currently working with Alaska to identify various CO control strategies and options to address the areas CO problems. Area is not implementing oxy program.
Anchorage, Alaska	11/1 - 2/29 2.7%	100% Ethanol	Ethanol only program. Will Implement program for the 99/00 season. Final redesignation to CO "serious" non-attainment area was published in the FR on 6-12-98 (63 FR 32128-32131). EPA is currently working with Alaska to identify various CO control strategies and options to address the areas CO problems.
Spokane, Washington	9/1 - 2/29 3.5%	100% Ethanol	Final redesignation to CO "serious" non-attainment area was published in the FR on 3-12-98 (63 FR 12007-12013).

The volumes of oxygenated gasoline sold in the United States are reported by the EIA. The sales are seasonal with high demand in the winter months. Table 6-5 shows sales for each month in 1999 and annual sales for the previous five years. In the early years of the program a number of regions used MTBE and not ethanol so the implied ethanol demand is overstated in these years. It is also apparent from the table that the number of regions in non-compliance with carbon monoxide standards has decline over the duration of the program. In some areas ethanol may be blended at less than the 10% level and thus the implied demand shown in the table may also be overstated.

Table 6-5 Oxygenated Gasoline Sales in the United States

Period	Oxygenated Gasoline Sales	Implied Ethanol Demand
Units	Million litres per day	Million litres per year
1994	94.5	3,449
1995	42.7	1,558
1996	28.7	1,047
1997	23.8	869
1998	30.6	1,116
1999		
January	41.2	
February	43.1	
March	34.8	
April	21.2	
May	21.9	
June	24.2	
July	24.2	
August	23.4	
September	27.2	
October	38.2	
November	48.8	
December	52.5	
Average 1999	33.3	1,215

The other fuel related program introduced with the Clean Air Act of 1990 was for areas that were ozone non-attainment areas. The concept of reformulated gasoline (RFG) was originally generated, developed, and promoted by industry, not the Environmental Protection Agency (EPA) or other parts of the federal government.

The Clean Air Act legislation President Bush sent to Congress in 1990 included a number of provisions that would have led to the introduction of alternative (non-petroleum) fuels. The petroleum and oxygenate industries responded to these provisions by offering the RFG program as a substitute for most of the alternative fuel provisions.

Their argument, which ultimately succeeded, was that significant fleet turnover would need to occur before emission reductions could be realized from alternative fuels. RFG, on the other hand, would be effective immediately in the existing fleet.

The final Clean Air Act legislation not only set emission performance requirements for RFG, but it also included a mandate for RFG to contain 2% wt. oxygenates.

Throughout much of 1991, EPA participated in a regulatory negotiation process with the petroleum industry, oxygenate industry, state and local organizations, environmental groups, auto manufacturers, organizations representing the public, and other government agencies to lay out the framework for the RFG rulemaking.

The automobile manufacturers and oil companies voluntarily invested millions of dollars in a joint research program, the "Auto/Oil Air Quality Improvement Research Program," to quantify the emission impacts of changes in the quality of gasoline.

The results of the Auto/Oil program and numerous other studies conducted by EPA and industry revealed that large emission benefits were indeed possible and cost- effective through RFG. As a result, the emission standards for RFG in the year 2000 go beyond the minimum requirements specified in the Clean Air Act.

The RFG program was mandated to be implemented only in the nine cities in the country with the extreme or severe ozone non-attainment (Los Angeles, San Diego, Chicago, Houston, Milwaukee, Baltimore, Philadelphia, Hartford, and New York City). The fuel was introduced to the market in 1995. Sacramento was added later.

In addition, many other areas which also have a history of smog problems were requested to be included in the program by the State Governors. EPA expanded the program to cover these areas. The current areas covered by the RFG program are shown in Table 6-6.

Table 6-6 Reformulated Gasoline Areas in the United States

Region	Mandatory or Opt-in	Comments
LOS ANGELES	Mandatory	
SAN DIEGO County	Mandatory	
HARTFORD - New Haven - Waterbury, CT	Mandatory	
NEW YORK - Northern New Jersey - Long Island - Connecticut area, NY-NJ-CT	Mandatory	
PHILADELPHIA - Wilmington - Trenton - Cecil County, MD area PA-NJ-DE-MD	Mandatory	
CHICAGO - Gary - Lake County, IL - Indiana - Wisconsin area	Mandatory	100% ethanol as oxygenate
BALTIMORE, MD	Mandatory	
HOUSTON - Galveston - Brazoria, TX	Mandatory	
MILWAUKEE - Racine, WI	Mandatory	100% ethanol as oxygenate
SACRAMENTO, CA (newly required area)	Mandatory	
CONNECTICUT, The Entire State	Opt-in	
DELAWARE, The Entire State	Opt-in	
DISTRICT OF COLUMBIA	Opt-in	
KENTUCKY Cincinnati-Hamilton KY-OH area (KY portion) Louisville, KY-IN area (KY portion)	Opt-in	25% ethanol, 75% MTBE as oxygenate
MARYLAND Washington, DC-MD-VA area (MD portion) Kent & Queen Anne's non-attainment area	Opt-in	
MASSACHUSETTS, The Entire State 1	Opt-in	
MISSOURI St. Louis non-attainment area	Opt-in	
NEW HAMPSHIRE Boston-Lawrence-Worcester, MA-NH non-attainment area (NH portion)	Opt-in	
NEW JERSEY, The Entire State	Opt-in	
NEW YORK Essex non-attainment area	Opt-in	
RHODE ISLAND, The Entire State	Opt-in	
TEXAS Dallas-Fort Worth non-attainment area	Opt-in	
VIRGINIA Washington DC-MD-VA area (VA portion) Richmond, VA non-attainment area Norfolk-Virginia Beach-Newport News area	Opt-in	

The proportion of RFG that uses ethanol versus MTBE has been increasing slowly over the years. The use of each oxygenate in the month of March for the past five years is shown in Table 6-7 (DeWitt, 2000). This program has also been very effective at increasing demand for ethanol as an oxygenate.

Table 6-7 Oxygenate Use in Reformulated Gasoline

Date	MTBE	Ethanol	% Ethanol
units	1000 bbls/day	1000 bbls/day	
March 1996	222	22.8	10.4
March 1997	236	22.1	9.8
March 1998	228	28.6	12.0
March 1999	249	37.2	15.5
March 2000	273	41.3	15.4

The use of MTBE as the oxygenate in RFG is under attack in many areas of the United States. MTBE has been found in ground water, lakes and rivers throughout most of the United States. The most likely sources of MTBE are leaky underground storage tanks and the use of two stroke engines on lakes. The state of California has taken the lead in banning MTBE from gasoline used in the state. This is supposed to be effective no later than December 2002. California has also requested a waiver from the oxygenate requirements of the federal reformulated gasoline program. A number of other states have followed California and are moving to ban MTBE use in gasoline. The administration of the federal government has also introduced a legislative agenda to reduce the use of MTBE in gasoline. Depending on the outcome of the various initiatives the demand for ethanol could triple to about 13 billion litres per year within a few years.

In response to the administration move to reduce MTBE use the US Senate Environment and Public Works Committee held hearings on the issue and the committee has approved legislation to amend the Clean Air Act by banning MTBE use in four years and provide a mechanism for the waiver of the oxygen content of RFG. In addition the bill would create a requirement for increasing amounts of renewable fuels in motor fuels that would apply to all refiners, blenders and importers. The definition of renewable fuels would cover ethanol and biodiesel and ethanol from lignocellulosic materials would count as 1.5 times the volume of ethanol from grain. The renewable fuel requirement would be phased in between 2002 and 2011. It is anticipated that as much as 16 billion litres of ethanol demand could be created by 2011. The bill also contains a provision for a credit for very clean vehicle sales up to 10% of the renewable fuel requirement. The proposed bill must still be voted on by the whole Senate and the House and signed by the President before it becomes law.

There are no formal programs in the United States that address greenhouse gases. The level of activity is much the same as in Canada with work being undertaken to identify and evaluate options. The interest in cellulosic ethanol in the United States is driven in large part by the better GHG performance of those processes.

6.2 BIODIESEL

Biodiesel addresses many of the same environmental concerns for diesel fuel that ethanol does for gasoline. The following table highlights the impact of biodiesel on exhaust emissions from diesel engines when the fuel is used either as a blend with diesel fuel or as a neat fuel. The wide variation in the data is evidence of the influence of engine design on the emissions. Diesel fuel quality is substantially lower in North America than in Europe and while biodiesel has no impact or even lowers cetane number in European diesel fuels it substantially increases diesel fuel quality in North America. This fact and the significant differences in diesel engine design between the two regions may result in the following results being specific to North America.

Table 6-8: Impact of Biodiesel on Exhaust Emissions

Parameter	20% Biodiesel	100% Biodiesel
Particulate Matter	-5 to –15%	+27 to –68%
Total hydrocarbons	-15 to –20%	-37 to –63%
Nitrogen oxides	+1 to +5%	-8 to + 8%
Carbon monoxide	-2 to –16%	-33 to –46%
Sulphur oxides	-20%	-100%
Power	0 to –2%	0 to –5%

Biodiesel also reduces emissions of greenhouse gases. The reductions are strongly dependent on the feedstocks used and the processes employed. The results for Canada using Canola Oil (Levelton, 1999) and for the United States (Wang, 1999b) using soy oil are shown in Table 6-9. There are significant differences in the fertilizer requirements and the relative proportions of oil and meal of the two crops. These may account for the large difference in GHG performance of the two fuels. What is clear from the studies is that biodiesel does reduce GHG emissions compared to petroleum diesel fuel.

Table 6-9 Greenhouse Gas Emission Reductions from Biodiesel

	United States	Canada
	Reductions in GHG Emissions	Reductions in GHG Emissions
100% Biodiesel		51%
20% Biodiesel	40.5%	

6.2.1 Canada

Just as there are no specific environmental programs in Canada that would require ethanol to be added to gasoline there are no programs for biodiesel either. Interest in biodiesel from an environmental perspective in Canada has been limited to studies of its potential for use in underground mining vehicles (DEEP). No proposal have been generated that would require its use in those applications.

6.2.2 United States

There are no specific provisions of the Clean Air Act of 1990 that require the use of biodiesel or biodiesel blends to be used in the United States. Biodiesel is certainly being promoted in part for its environmental benefits but there are no programs that would require its use.

7. PUBLIC OPINIONS TOWARDS ALTERNATIVE FUELS

Throughout North America consumers have a choice as to where to buy their transportation fuels. They consider many factors when they make that decision. Most customers look for convenient locations, friendly helpful service, clean, pleasant stations, quality fuel products, honest, trustworthy, concerned and responsive companies, and price. Many consider the availability of full service and the involvement the company and its employees may have in the community and some consider the availability of reward programs, special offers, credit cards, and whether or not a convenience store is also present on the site.

Most of these attributes deal with the company or location of the station and not with the product itself. The focus of this study is the specific product attributes of biofuels and whether they are strong enough to overcome a price disadvantage to some customers. With so many factors influencing consumer buying habits the issues are complex and it is difficult to accurately isolate just one or two variables in the equation. Some companies have had experience with this issue and the results are shared in the following sections.

Biofuels do have specific product attributes that some customers will pay more for. Both ethanol blended gasoline and biodiesel blends reduce exhaust emission of criteria air contaminants, both produce fewer greenhouse gases than petroleum based gasoline and diesel fuel and depending on how they are blended provide higher octane or cetane and better performance.

Communication is one of the key enablers for the successful introduction of innovations to the market. In most places in North America the positive attributes of biofuels have not been adequately marketed to the consumer and thus few companies have been able to take advantage of the attributes. There are some exceptions and some detailed information is available for some of the situations.

7.1 ETHANOL

Ethanol blended gasolines can offer higher octane than ordinary gasoline, they are oxygenated and thus reduce exhaust emissions, they are made from grain and thus provide needed markets for local commodities and are renewable which produces lower greenhouse gas emissions. The production of ethanol creates more jobs than producing gasoline at a refinery and thus there is a local economic benefit often associated with ethanol use. The alcohol portion provides protection against gas line freezing, an important attribute in cold winter climates. These fuel qualities give ethanol a perceived relative advantage over gasoline in the eyes of many customers.

A perceived relative advantage is critical for the successful diffusion of new products. In addition the product should be compatible with existing systems, which blended biofuels are, they need to be observable and trialable and again the blended fuels meet this criteria. Innovations ideally should be less complex than existing systems and biofuels would not be less complex but they are not more complex either.

Ethanol does cost more to produce than gasoline and thus it is considered to be dependent on tax incentives to make it commercially viable for the fuel marketer. One of the Canadian marketers of ethanol blended gasolines, Mohawk Canada Ltd. sold the fuel in regions without large tax incentives with significant success. More detail on that program is provided below.

7.1.1 Canada

There is one significant difference between Canada and the United States in gasoline retailing that must be understood. In Canada there is no brand premium, all retailers sell regular gasoline at essentially the same price. This characteristic of the market makes it impossible for regular gasoline with ethanol to be sold at a lower or higher price than ordinary regular gasoline. This is usually attributed to the price sensitivity of the Canadian consumer but is probably also an indication of the competitiveness of the retail gasoline sector. The experience with differential pricing of ethanol gasoline blends in Canada is therefore mostly with mid-grade and premium gasoline.

7.1.1.1 Mohawk Canada Ltd. Experience

Ethanol blended gasoline was introduced in Canada in October 1981 by Mohawk in the Province of Manitoba. There was a significant Provincial tax incentive available, which made the product commercially viable when sold at the same price as regular gasoline. Mohawk advertised the product attributes extensively and experienced a very significant increase (400%) in sales volume over the first six months of the program. Sales dropped off (but were still about double the previous year) in the spring of 1982 as the weather warmed and the importance of gas line antifreeze dropped in the consumers' mind. Mohawk experienced increases in winter sales of the product in cold regions of the country every winter after the first season.

The lack of federal tax incentives or incentives in other provinces limited the growth of ethanol blended gasoline in Canada until 1988. In that year Mohawk began to offer blends of 5% ethanol in premium gasoline at all of its service stations in Western Canada. This was done without tax incentives in all markets other than Manitoba. The fuel was marketed as the highest octane unleaded gasoline available in the market and was sold for 0.2 cents per litre more than the highest priced major oil company premium gasoline. Sales increased and Mohawk had premium gasoline product splits the same or higher than all of the major oil companies. This was a significant accomplishment for an independent oil marketer. Mohawk experienced a growth in market share and a growth in the high margin premium category at a relatively low cost.

In 1992 Mohawk introduced regular grade gasoline that was blended with 5% ethanol. Some provinces and the federal government had introduced tax incentives for ethanol by this time. In those provinces with tax incentives the product was sold at the same price as regular gasoline and in provinces without a provincial tax incentives it was sold at 1 cent/litre more than regular but 1 cent/litre less than major oil company mid grade unleaded gasoline. The product attributes were higher octane than regular, lower exhaust emissions and renewable ethanol for the same price as regular unleaded gasoline. Sales in the Province of British Columbia where it was sold for more than regular can be compared to the sales in the adjacent Province of Alberta where it sold for the same price. This was in effect a real world marketing test of the consumers' willingness to pay more for a product with a perceived relative advantage. The product splits for the two provinces are shown in Table 7-1.

Table 7-1 Mohawk Canada Product Splits – 1992

	British Columbia	Alberta
Regular Unleaded	64	15
Regular Unleaded + 5% Ethanol	20	77
Premium Unleaded + 10% Ethanol	16	8

There are two important points to the table, the first is that given a choice, most consumers in Alberta purchased the higher octane, cleaner burning fuel; and the second is that the 20% of the customers in British Columbia that purchased the 5% ethanol blended product was a much higher share than most companies had for their mid-grade sales.

Through the 1990's there was a trend in the industry in Canada to reduce margins on regular unleaded gasoline and increase the retail margin on the mid grade and premium gasolines. This meant that the differential between regular and mid grade increased from 2 cents /litre in 1992 to 5 cents/litre in 1997 and likewise the spread between regular and premium increased from 5 cents/litre to 10 cents/litre. Mohawk followed this practice and by 1997 the spread between regular and the same gasoline with 5% ethanol was 5 cents/litre. There was very little impact on sales splits as shown in Table 7-2. It was difficult to get customers to pay more for the product but once they were, sales were relatively independent of how much more. Throughout this time period Mohawk regularly advertised the product attributes and customer benefits through mass-market communications and through point of sale contact with the customers. The clean burning benefits were further enforced in the customers mind by the requirement for annual emission testing of each vehicle and the word of mouth transmission of anecdotes of vehicles that had failed the test passing when fuelled with ethanol gasoline blends.

In 1996 in response to some changes in ethanol tax incentives, Mohawk decided to increase the price of regular with ethanol in the Province of Alberta. In part of the Province the price was increased by 1 cent/litre and in part by 2 cents/litre. The sales split began to shift almost immediately, many customers who had purchased the ethanol product at the same price as regular did not believe there was enough value in the positive product attributes to continue purchasing the product and they switched to regular unleaded. The overall sales at Mohawk stations stayed constant through these changes. There was no difference found in the areas that had a 1-cent increase compared to the regions with a 2-cent/litre increase. This reinforces the previous experience in British Columbia. In 1997 after approximately one year the product splits in Alberta had stabilized at the values shown in Table 7-2.

Table 7-2 Mohawk Canada Product Splits – 1997

	British Columbia	Alberta
Regular Unleaded	65	60
Regular Unleaded + 5% Ethanol	19	33
Premium Unleaded + 10% Ethanol	16	7

The percentage of price sensitive regular customers was not significantly different in the two regions once all ethanol-blended gasoline was priced higher than ordinary gasoline. The differences in premium gasoline sales between the two regions was similar to the rest of the industry and is accounted for by a different mix of vehicles and different terrain with British Columbia having a higher octane demand.

Focus group research conducted by Mohawk with its regular with ethanol customers found that the customers purchased the gasoline first because it was cleaner burning and secondly because it provided better performance in their vehicles.

In 1994 Mohawk initiated consumer research to learn more about how customers think, what motivated them to choose one service station over another and how they chose the grade of gasoline. The research segregated customers into five classes. Approximately 1000 customers were interviewed. The five customer profiles developed were:

- performance motivated
- environmentally concerned
- price motivated
- full-service and
- convenience.

Customers are not one-dimensional and all of the attributes were important to some degree to all customers but customers could be classified according to the most important attribute to them.

The performance motivated customers were knowledgeable about fuel, experimental, had nontraditional values, they were science and technology buffs, they enjoyed working on car, and they were willing to pay for the best fuel. They also had a strong interest in the environment but were different than the environmentally motivated consumers. They had an emotional attachment to their vehicle.

The environmentally motivated customers were involved, responsible individuals, forward thinking, but not innovators. This lack of innovation makes them quite different from the performance motivated consumer. They only had a moderate interest in science and technology but they did feel that they could make a difference. They too were willing to pay more for a clean fuel.

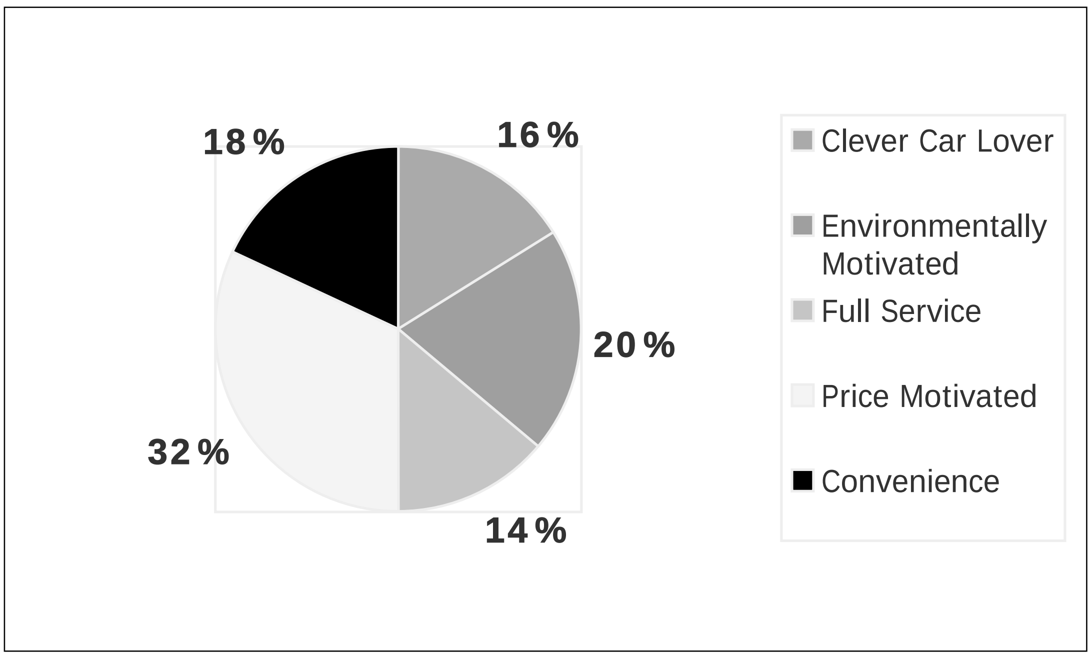
The price motivated consumer were conservative, only mildly knowledgeable about fuel, not innovative and tended to be inner directed. “Cars are cars” and of course won't pay more for quality fuels.

The full-service people were mechanically challenge, they were quality conscious, they would try new things but had little interest in science and technology. They would pay more only for full-service.

The last category was people who looked for convenience, They had little interest in science and technology, lived for today, and would not pay more for fuel quality.

In Western Canada Mohawk found that the distribution of customers in these five market segments was as shown in Figure 7-1.

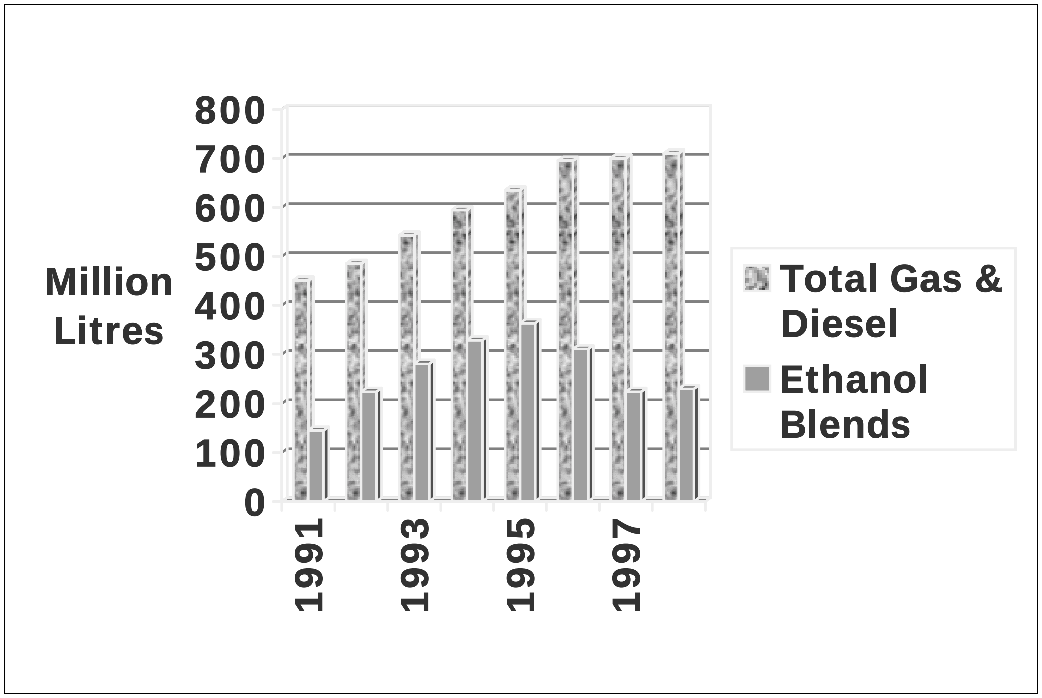
Figure 7-1 Customer Segmentation in Western Canada



The two categories that were willing to pay for fuel quality totaled about 36% of Western Canada customers. This is very close to the 35 to 40% of customers that were purchasing the ethanol-blended fuels at a higher price from Mohawk as shown in Table 7-2.

In Figure 7-2 the growth in retail fuel sales experienced by Mohawk from 1991 to 1998 is shown. Also shown is the growth in sales of ethanol blended gasoline. This overall growth was accomplished with the same number of service stations each year in a market that was only growing at 1 to 2 percent per year. In 1996 Mohawk began to the experiment with the pricing of ethanol blended products to capture more margin. It is apparent that some ethanol customers switched back to regular gasoline when the price was increased. It does not appear that any sales were lost during this process.

Figure 7-2 Mohawk Sales Growth



7.1.1.2 Other Canadian Experience

A survey of Canadian conducted for Ernst and Young (Ernst and Young 1999) in 1999 was aimed at determining if Canadians were willing to pay more for vehicles that had lower emissions. Over 2000 people were interviewed. Over 40% of respondents would expect to pay more for greener vehicles and 34% expressed a willingness to pay more. Of those who expected to pay more 11% were willing to pay $5,000 (Can) more, 42% were willing to pay $2,000 more and the remainder ranged from $50 to $500 more. The 34% expressing a willingness to pay an average of $1700 more for a cleaner vehicle are very similar to the portions that Mohawk found were willing to pay more for a cleaner fuel.

The experience with ethanol gasoline blends in eastern Canada is primarily with the refiner-marketer Sunoco and a number of small independents. Sunoco uses ethanol in all three of the grades of gasoline sold at their stations in Ontario. The fuels have the same octane as their competitors and are sold at the same price as competing grades. Sunoco releases very little information regarding their marketing programs but at a Canadian Renewable Fuels Annual Meeting in 1998, after six months experience with the program a spokesman did state that Sunoco had received a good response from their customers and that their sales were up but by less than 10%. Interestingly they used slightly different communications strategies in the different parts of the province. In some areas the performance attributes were emphasized more than the environmental benefits and in other areas the opposite strategy was used. Sunoco had experienced the best response where the performance aspects were emphasized. This would be consistent with Mohawk's findings that performance motivated customers are earlier adopters than environmentally motivated customers.

The independent marketers in Ontario generally sell ethanol-blended gasoline as their 89 octane mid grade offering. The product is made from 87 octane unleaded gasoline and 10% ethanol and is usually priced 1 to 3 cents per litre above the regular octane gasoline. The marketers thus get some octane value from the ethanol, in addition they save 2 cents per litre on the rack price of mid grade gasoline and pass that saving on to the customer by pricing the 89 octane ethanol blended fuel lower than competitors 89 octane all hydrocarbon midgrade. Some marketers have experienced an increase in mid grade sales due to the ethanol.

7.1.2 United States

Unlike Canada, gasoline marketing in the United States does allow some price differentiation between brands. The top ten rack to retail margin brands for the western United States were recently identified in OPIS Retail Report (OPIS). That data is shown in Table 7-3. While this table is not specific to ethanol it does indicate that if a marketer could enhance its brand image that perhaps one cent per litre (the difference between the average margin and the top or bottom margin) could be available in the market from an enhanced brand image. None of the companies identified in this table have used ethanol to enhance brand image.

Table 7-3 Rack to Retail Margins by Brand

	Margin Feb. 2000	Margin Feb. 1999
	Cents/litre	Cents/litre
Shell	4.62	5.30
Texaco	4.17	5.17
Chevron	4.07	4.97
Phillips 66	3.57	3.72
Mobil	3.44	4.45
Tesoro	3.39	4.39
Fina	3.39	4.10
Thriftway	3.38	3.44
BP	2.83	4.97
Total	2.57	5.89

At the Renewable Fuels Association's 1998 Ethanol Policy & Marketing meeting several keynote presentations had the theme that ethanol was a great product, increasing gasoline octane, reducing emissions and helping the farmer but it sold at a discount to gasoline. This was a time of low gasoline prices and uncertainty over the extension of the federal tax exemption in the United States. The ethanol market has developed differently in the United States than it has in Canada, which may help to explain the lack of a premium price for ethanol blended gasolines.

Two of the major programs in the United States that create demand for ethanol are the oxygenated gasoline program and the RFG program and the requirements of the programs apply to all of the companies operating in a region. These programs severely limit the ability to differentiate products through product formulations except perhaps in a negative way. Getty Petroleum in the Northeast has used ethanol in RFG areas and has advertised that its gasolines contain no MTBE. These mandatory programs also have a tendency to increase gasoline prices, which will instil some consumer backlash in at least the price sensitive market sector. These two programs account for over half of the ethanol used in the United States. The programs have helped to build demand but have probably worked against building a positive image for ethanol blended gasolines.

In areas where ethanol is used voluntarily it is often used for its ability to extend retail margins and boost octane. In that respect the consumer is paying for ethanol's attributes. The lower product cost however is often used to build volume by selling the product at a lower price. Many of the companies using ethanol are members of the Society of Independent Gasoline Marketers of America (SIGMA). SIGMA members sell 134 billion litres of gasoline per year and 23% is blended with ethanol. At 10% ethanol this represents 3 billion litres of ethanol per year, some of the ethanol will be used at less than 10% but SIGMA members still represent about one half of all ethanol sold for fuel use. The median sales by a SIGMA member are 300 million litres per year of gasoline and diesel fuel. A SIGMA member may sell both private branded gasoline and a major brand or several major brands. The multiple brands will dilute the marketing efforts and thus many SIGMA companies will be too small to be able to devote the resources necessary to effectively market the ethanol attributes to attract a higher selling price.

Opinion polls conducted in the United States do not provide a clear and strong indication of the publics willingness to pay more for ethanol blended gasoline. Different polls have reached different conclusions. Gasoline prices in parts of the United States reached $0.60 per litre during June 2000. There were a variety of reasons for this but there was a very strong and negative public reaction to the high price. The issue was given significant attention in the national news media and there were government led inquiries as to the reasons for the price increases. An about.com poll of 407 Internet users found that 77% believed that the government should take an active roll in regulating gasoline prices.

DeWitt (DeWitt, 2000b) reported on premium gasoline share in the United States and found a significant correlation between gasoline price and premium gasoline share. When prices were high the premium share dropped as consumers tried to reduce gasoline expenditures without reducing gasoline use. It was reported that the trend was not totally reversible with premium gasoline share not rising to previous levels when gasoline prices dropped again. There is thus evidence that US gasoline purchasers are very sensitive to gasoline prices in spite of having some of the lowest gasoline prices in the industrialized world.

Some opinion polls provide conflicting views. A November 1997 poll by the Pew Research Centre (Pew, 1997) investigate attitudes toward climate change. It found that 24% of people were greatly concerned about the greenhouse effect, which was a drop from 30% in 1990. The poll found surprisingly high support for higher gasoline prices to help reduce global warming. The questions were split among the 1200 respondents with 73% of one half of the group indicating a willingness to pay 1.3 cents per litre more for gasoline and 60% of the other half willing to pay 6.6 cents per litre more for gasoline.

Polls typically find a stronger willingness to accept changes when the changes can be related to a desirable outcome. Another example of this was a 1996 Sustainable Energy Coalition poll that found that 73% of respondents said that cutting taxes made some difference in how they voted a majority (52%) of voters supported tax incentives for renewable energy or energy efficiency initiatives. The context in which questions are asked is obviously important since this poll found that 71% of voters viewed climate change as a serious threat, a far different number than the Pew poll a year later. This reinforces the need for communications to sell positive product attributes to the consumer if changes in buying habits are desired.

A survey (Clean Air Trust) conducted for the American Lung Association, Environmental Defence and the Clean Air Trust on the subject of diesel fuel cleanup found that 85% of respondents think that 1 cent per litre is a reasonable price to pay for cleaner diesel fuel, 50% thought 1.85 cents per litre was reasonable, 35% thought 2.6 cents per litre was appropriate, 13% said 5.3 cents per litre and 6% said over 5.3 cents per litre would be acceptable. The poll was conducted in June 2000 with 1000 adults.

7.2 BIODIESEL

There has been only limited experience with biodiesel in Canada and the United States to determine if there is a consumer preference for the fuel or a willingness to pay extra for it. The broadest experience has been with biodiesel's use as an additive at low concentrations.

In May 1999, Koch Petroleum Group, L.P., introduced two diesel fuels with biodiesel in four midwestern states, including Kansas, Nebraska, Minnesota and South Dakota. The fuels – the nation's first pre-mixed, precision-blended soybean oil fuels – were primarily available to farm customers of rural co-operatives and distributors. The two fuels have different cetane ratings and sell for 1 to 1.3 cents per litre more than ordinary diesel fuel. Koch is supporting the introduction of these fuels with a significant communications effort to raise awareness of the product.

The product acceptance appears to be good. After test-marketing the products for three months, Koch added distribution locations in Iowa and South Dakota. According to Koch this expansion was due to high farmer acceptance, plus a growing interest from urban bus and truck fleet operators.

In March 2000 the fuels were introduced into major metropolitan areas in Minnesota's three largest cities: Minneapolis, St. Paul and Rochester. This offering represents a major increase (well over 200%) in potential reach for these two premium diesel products.

In June 2000 Koch introduced one of the products to the Quality Oil Company terminal in Holland, Michigan.

The experience of Koch would appear to indicate some consumer preference for diesel fuel blended with some biodiesel even at a slightly higher price when combined with an effective communication program to reinforce the positive product attributes.

8. SOCIO-ECONOMIC IMPLICATIONS OF ALTERNATIVE FUELS

Numerous socio-economic studies of ethanol and biodiesel production and use in various jurisdictions have been performed over the past two decades. Approximately 25 of these studies are reviewed below. Most studies were related to ethanol from corn and were carried out for areas of the United States while a few were undertaken for Canada. There are a few biodiesel specific studies. There is considerable variation in the scope, approaches and methodologies applied in these studies.

Most of the analyses concluded that the extra demand for feed grains (mostly corn) had some upward impact on feed grain prices. The amount of the increase varies year by year due to changes in the overall supply-demand balance. The studies that considered the whole US market have price increases for corn of 20 to 45 cents per bushel due to the demand created by ethanol production. Due to the interdependent nature of North American feed grain markets Canadian producers have also received some benefit from this extra demand.

Most of the studies reported an increase in the number of jobs due to the production of ethanol. These jobs are weighted towards the rural sector of the economy but indirect benefits accrue to all sectors of the economy. Most of the studies also report an increase in Gross Domestic Product (GDP) related to the demand for grain and the production of ethanol. However, these results are mostly in regions that have large rural populations, and lack an oil refining industry.

The studies are not consistent in their determination of overall costs and benefits to the economy. As a result the conclusions of the reports vary with respect to the costs and benefit analyses. Some conclude that the costs to governments and society outweigh the benefits and others reach the opposite conclusion. That is, the benefits are greater than the costs and that government expenditures drop as a result of ethanol fuel tax exemptions. Some studies are also internally inconsistent in how they treat issues such as ethanol's lower energy content. They calculate the lost government revenue from the ethanol portion of fuels but do not include the extra fuel tax revenue from the extra gasoline sales caused by the lower fuel economy.

A brief overview of the most recent studies presented by country and in chronological order follows. The key findings, limitations, and unique aspects of the studies are highlighted.

8.1 UNITED STATES ETHANOL STUDIES

Economic Analysis of Replacing MTBE with Ethanol in the United States. USDA, 1999

This paper analyzes the effects of replacing MTBE with ethanol. The analysis assumed that all MTBE in the US is phased out and replaced with ethanol on an equivalent oxygen basis. The replacement happens gradually over the 2000 to 2004 time period. The USDA used an econometric model to estimate crop production, use and prices of major crops and livestock prices, retail food prices, and net farm income. An input-output model was used to determine the impact on employment.

The scenario modeled resulted in a doubling of US ethanol production to 3.0 billion USG per year by 2004 compared to the business as usual scenario. The average price increase for corn over the 2000-2010 period was forecast to be 14 cents per bushel. This is in addition to the price increases already caused by the current production level of 1.5 billion gallons per year. Other feed grain prices also increase while soybean prices decline due to the increased production of high protein feeds from the ethanol plant. Farm cash receipts average $1.0 billion more over the ten-year period.

The increase in farm and ethanol production creates an additional 13,000 new jobs across the economy by 2010.

The US trade balance is expected to improve by $1.3 billion per year. This is caused by a $200 million increase in agricultural exports and a $1.1 billion per year decrease in US MTBE imports.

There is the potential for a decrease in US farm program costs over the period due to the higher farm income. The USDA is currently projecting the farm prices for the next decade will be above the threshold where the loan deficiency payments and marketing loans will kick in and thus payments under these programs are minimal. The higher farm prices caused by expanded ethanol production will not have an impact on these programs provided prices stay above the minimum set by the programs. It is acknowledged that farm prices are highly volatile and if commodity prices drop below current forecasts these programs could start to make payments and thus there may be future savings caused by the higher corn prices and farm incomes. It should be noted that the current USDA estimate for the year 2000 projects a $33.5 billion (US) expenditure for farm support programs. This is $10 billion more than 1999 and is due to the increased need to address farm income and natural disaster issues (USDA 2000).

The Costs and Benefits of State-Level Oxygenate Mandates to Expand Ethanol Production. American Petroleum Institute, January 1999.

The principal purpose of this paper was to assess the likely costs and benefits of additional state level mandates that were being considered by various state assemblies. The analysis concentrates on the state of Minnesota and calculates the costs and benefits from the mandated program in that state. The paper concludes that the costs outweigh the benefits by a factor of over four to one. Details of the calculations of costs and benefits are shown below.

The benefits to corn producers are calculated from the production margin on incremental corn production required to meet the ethanol demand in Minnesota. The production margin is estimated at $0.64 per bushel and the increased demand is 52.8 million bushels for a benefit of $25.8 million. The report suggests that the extra demand will increase corn prices by $0.04 to 0.05 per bushel but does not calculate or include the benefit to the producers from this higher price. The total increase in revenue from corn produced in the state from a $0.04 per bushel increase is $44 million.

The indirect benefits accruing to the agricultural sector are calculated from the feed grain multiplier of 2.0 derived from the US input-output accounts. The benefits are calculated from the assumed incremental production of corn of 52.8 million bushels at $2.19 per bushel and the factor of 2.0 for a total of $115.6 million in extra economic activity from the incremental corn production. The study further assumes that a 10% profit margin on this activity yields a net benefit of $11.6 million. It is not clear why incremental production margins were used for the corn production but average production margins are used for the indirect benefits.

There are no direct or indirect benefits calculated from the increase in employment or economic activity associated with the production of ethanol. The total benefits are calculated to be $37.4 million ($25.8 million + $11.6 million).

The costs of a mandated program are calculated from three components, higher prices paid by consumers, lost revenue from State ethanol incentives and Federal tax exemptions. The higher gasoline prices are supported by comparisons of retail prices in Minnesota compared to fourteen other states in the mid west over a five week period in November and December 1998. The difference in retail prices was $0.03 per gallon. No adjustments were made for different tax levels in the various states nor for different competitive wholesale and retail scenarios or distribution costs. The cost difference is further supported by a comparison of ethanol prices of $1.20 per gallon and wholesale gasoline prices of $0.30 per gallon. No time reference is given for this comparison and while the ethanol price is not unusual for Minnesota the gasoline price corresponds to a crude oil price of less than $10 per barrel which is highly unusual. Current wholesale gasoline prices are about $0.80 per gallon. This cost to consumers is calculated to be $50 million per year.

The cost of the state incentives is calculated to be $26.7 million per year (132 million gallons at $0.20 per gallon and $300,000 in loan rate subsidies). The federal tax exemption is calculated to be $79.9 million (based on $0.54 per gallon plus the small producer payments of $0.10 per gallon on production from plants of less than 15 million gallons per year. The total costs calculated are $156.6 million. Approximately one third of that is based on a snapshot of market conditions.

This study is certainly one of the least rigorous of the socio-economic studies performed on ethanol. The data chosen would appear to overestimate the costs, underestimate the benefits and in fact would not appear to include all of the potential benefits. For example the impact on corn prices in other areas of the US is not calculated.

Ethanol Tax Incentives and Issues. David Andress and Associates for the US Department of Energy. April 1998

This is not a socio-economic study per se but rather an analysis of the actual cost of the US Federal Tax exemption and typical state programs. The conclusions are that nominal incentive values for the Federal and State programs overstate the true cost to governments for several reasons. The first is that fuel taxes are applied volumetrically and ethanol only has about 65% of the energy of gasoline. Consumers therefore must purchase more gasoline to travel the same distance and the tax revenues to the government increase. The US $0.54 per gallon ethanol incentive therefore costs the government only $0.479 per gallon ($0.54-1/3*$0.184(the gasoline tax rate)). This principle applies to both federal and state programs. Secondly the US treats the ethanol income tax credit as revenue and thus it is taxed at the taxpayers marginal rate. Thirdly, there will be some increase in the domestic tax base from the increased economic activity resulting from the ethanol production.

For states that do not provide differential taxation for ethanol, the report correctly points out collect more fuel tax when 10% ethanol is used. Based on a typical US State fuel tax of 20 cents per gallon the additional state revenue is 6.7 cents per gallon. The total cost to governments of the $0.54 per gallon incentive is then typically $0.412 per gallon.

The paper's calculation of the impact of the income tax benefit is probably overstated since most blenders utilize the excise tax exemption rather than the income tax credit. It is well established in the US that the income tax credit has less value. This is due to the fact that it is taxable and only recoverable once per year against income taxes owing.

The key finding of this study is the lower impact of ethanol's energy content on lost government revenues.

The Economic Impact of the Demand for Ethanol. Michael K. Evans, Kellogg School of Management, Northwestern University. February 1997.

This study which was commissioned by the Governors' Ethanol Coalition is based on econometric modelling of the US corn and ethanol industries. The key conclusions from the study were:

1. The 1997 ethanol demand of 1.52 billion gallons (not all fuel use) created a demand for 0.60 billion bushels of corn. This resulted in net new demand of 0.42 billion bushels and a reduction of 0.18 billion bushels of exports and other uses. This higher demand increased corn prices by $0.45 per bushel
2. The higher corn price increased net farm incomes by $4.5 billion.
3. The higher farm income combined with multiplier effects boosted employment by 169,000 in 1997. Most of this was off farm.
4. Further employment gains of 13,300 jobs in the ethanol industry including indirect jobs and 12,500 jobs including indirect jobs due to farm equipment purchases were recorded.
5. The total employment increase was 195,200 jobs.

6. The corn growing states experienced $465 million higher state and local tax receipts due to the economic activity.
7. Federal tax receipts increased by $3.6 billion and unemployment payments declined by $0.6 billion. This includes personnel income tax, corporate income tax, and social security payments.
8. The cost of the federal fuel ethanol subsidy was $0.6 billion in 1997.
9. Increases in food prices due to ethanol demand was fully offset by declines in energy prices resulting in no net impact on the cost of living.
10. Trade balance improved by $2.0 billion.

The primary driving force for the benefits is the increased demand for corn and the resulting higher price for the commodity. Impacts on farm income, employment, taxes, trade and balance of payments are all derived from changes in farm income. The author modeled corn prices with and without the demand for ethanol and compared the results to historical periods where there were large changes in corn exports. He concluded that the historical data supported the modelling results. The impact on corn prices has increased as demand for corn for ethanol production has increased. More discussion of the impact of demand on price is found in a later section.

Increases in corn prices were an order of magnitude higher than was used in the API study described earlier. This and the much more rigorous modelling of the economy performed for this study accounts for much of the different conclusions reached in the two reports. The study did not consider the energy content of the ethanol when it determined the costs to government.

Ethanol Programs. A Program Evaluation Report. State of Minnesota, Office of the Legislative Auditor. February 1997.

This report considers the cost and benefits of Minnesota's ethanol program from a state perspective. It does not consider the costs of the federal tax exemption, nor the impact on national corn prices. The authors used a state input-output model to determine the impact of the ethanol program on the state economy.

The report concludes that the state's support of ethanol has significant costs but produces net economic benefits. The net benefits are quantified at $109 to $260 million per year in addition to a one-time benefit of $174 to $261 from the construction of the plants. The wide ranges in benefits are primarily due to assumptions that the program could increase farm revenue some years and decrease it other years. This is due to the co-op structure of many of the ethanol plants where corn producers own the ethanol plants and are obligated to deliver corn to the plant. In years of low corn prices the ethanol plant may pay higher than market price for corn and in years of high corn prices it may pay less than the market price. A multiplier of 1.53 is used on farm income to determine the total economic impact. If no impact on corn price is assumed then the range of net benefits is calculated to be $167 to $202 million.

The benefits are determined by comparing the state economic output from $17 million spent on the ethanol program to the state output from an equivalent income tax reduction. The analysis assumes that the corn used for feedstock is incremental to farm production and income. The economic output from the ethanol program is therefore the total revenue generated from the ethanol and the DDG production. This totals $269 million for 1997 and can be compared to $20 million in economic activity generated by a $17 million tax cut. Note that the multiplier for the tax reduction is 1.18, considerably lower than the factor used for the agricultural sector.

The analysis calculated about 900 net jobs before the consideration of the impact of higher fuel costs.

The report calculates the impact of an ethanol mandate on annual fuel costs for consumers. The additional fuel costs of 2 to 3 cents per gallon for consumers are projected. In addition higher total costs arise from the lower energy content of the ethanol-blended gasoline and the determination that fuel costs will be higher for the oxygenated gasoline. The data that supports the assumption of higher prices is in part the same as sited in the API report. The data covers such a large area with different taxes, different competitive pressures it is difficult to reach absolute conclusions. Week to week price differences are much larger than the average values that the authors used to calculate total costs. Only nine weeks of data was used in the calculations. Some of the wholesale price data that is presented would suggest that conventional gasoline prices in Minnesota were 3 cents per gallon higher than the rest of the Midwest before the oxygen mandate was imposed. If that were the case then no additional cost has been imposed due to the ethanol mandate. The same multiplier is used for the extra fuel costs as the tax reduction since both should have similar impacts on consumer spending.

The total program costs calculated range from $67 to $102 million. This is comprised of $27 million in producer incentive and blender tax credit (since phased out) impact and $40 to $75 million in higher consumer fuel costs. The extra state fuel tax revenue from the increased fuel cost is not calculated and accounted for.

Tax Policy. Effects of the Alcohol Fuels Tax Incentives. United States General Accounting Office. March 1997.

This report was developed to address four specific issues;

1. Whom do the incentives benefit and disadvantage economically?
2. What environmental benefits, if any, have the incentives produced?
3. Have the incentives increased the nation's energy independence?
4. To what extent has the incentive reduced the flow of revenue to the Highway Trust Fund?

The study was not an socio-economic or cost/benefit analysis and the authors clearly state that it should not be used for that purpose.

The study found that fuel blenders, ethanol producers and corn and soybean farmers benefit from the tax exemption. The farmers benefit from higher commodity prices (9.3% for corn and 4.8% for soybeans). The total farm income is 2.4% higher because of the demand or ethanol production. The magnitude of the total benefits was not quantified. The tax incentives impact producers and consumer of alternative fuels to ethanol. The available evidence suggested that ethanol lowers gasoline prices by only a small amount (0.27 %). The consumer benefits from the lower gasoline price, which at least partially offsets the higher cost of food that higher grain prices would cause.

The impact on the environment was minimal in the view of the authors. In areas with air quality problems if ethanol wasn't used MTBE would be used instead and there would be no environmental impact. In areas that didn't require oxygenated fuel the view was that air quality would not degrade to the point that air quality standards were not met. It was thus concluded that ethanol had little environmental impact.

From the fact that ethanol only represents about 1% of the vehicle fuel consumption it was concluded that ethanol doesn't significantly reduce oil imports. This was rationalized by comparing oil import levels in 1978 with those in 1995 and finding no change. The fact that oil imports more than doubled between 1982 and 1995 is ignored.

It was determined that revenues flowing to the Highway Trust Fund were reduced by about $617 million in 1995.

The report acknowledged the need for stability in government programs. Without stability investors will not invest in new technologies and ventures. A number of comments from the US DOE and USDA are included in the report. Some of these comments disagree with the major conclusions reached by the authors.

Comments Concerning the Environmental Protection Agency's Regulations of Fuels and Fuel additives: Renewable Oxygenate Requirements for Reformulated Gasoline Proposed Rule. February 1994.

The USDA projected a 3-5 cent per bushel increase in the price of corn for every 100 million bushels of increased corn demand. At 1999 production levels this equates to increased corn prices of 18 to 30 cents per bushel. This higher farm income also resulted in lower deficiency payments under Farm support programs in place at the time. The savings in these programs was projected to be as much as $780 million.

The Economic Impacts of Renewable Energy Use in Wisconsin. April 1994. Wisconsin Energy Bureau, Division of Energy and Intergovernmental Relations.

This report discussed the impact of increased ethanol production within the state of Wisconsin. Higher corn prices from increased demand for ethanol will have the following economic impacts in the state;

1. Lower demand and price for soybeans,
2. Benefits to cattle and poultry producers from additional supply of high protein feeds,
3. Overall increases in net farm incomes,
4. Slight increase in food prices.

The study concluded that ethanol gasoline blends would not generate any loss of income or employment from the displacement of gasoline. The economic impacts from gasoline sales in Wisconsin is limited to the amount of state tax collected plus the marketing and transportation cost component of the fuel since there is no oil production or refining in the state.

Nebraska's Ethanol Industry. October 1993. Nebraska Department of Economic Development.

The state used an input/output economic model to determine the impact of an expanded ethanol industry in the state on job creation and personal and business income. It was projected that in 1995, 213 million gallons of ethanol would be produced in the state. This would create 455 direct jobs and 1599 indirect jobs. The direct to indirect multiplier for the ethanol plant jobs was 3.5. There were 2.13 jobs created in ethanol manufacturing per million gallons of annual production. The annual payroll would be $16.8 million and $2.4 million would be collected in state income and sales taxes. The state collected a further $2.1 million in taxes during the construction of the plants.

Ethanol Production and Employment. USDA, Economic Research Service. Agricultural Information Bulletin Number 678. July 1993.

This study reviewed the economic impacts of expanding ethanol production to 2 billion gallons by 1995 and to 5 billion gallons by 2000. This is considerably faster than the industry was able to expand. The emphasis was on job creation, agricultural implications, and tax revenues and budget implications. The 1992 ethanol production rate was 950 million gallons.

Increasing production to 2 billion gallons was forecast to create almost 28,000 jobs. These jobs would be distributed with 15,000 in farming and farm related activities, 10,000 direct and indirect in ethanol manufacturer (3500 direct) and 3500 construction jobs. The 5 billion gallon scenario creates 108,000 jobs, 34,000 in ethanol processing, 60,000 farm related and 14,000 temporary construction jobs.

The impact on commodity prices was forecast to be relatively small. Corn prices would increase by one cent per bushel at the 2 billion gallon level, although corn acreage would increase by 3.4%, at the 5 billion gallons level, corn prices rise by 19 cents per bushel and out put rises by 12%. Soybean prices and output would fall under both scenarios.

Higher commodity prices would result in lower government farm deficiency payments. At the 5 billion gallon production level farm deficiency payments drop by $870 million.

Ethanol and Agriculture: Effect of Increased Production on Crop and Livestock Sectors. USDA, Economic Research Service. Agricultural Economic Report Number 667. May 1993.

This is a similar study to the previous one but provides more detail of the impact on the agricultural sector. At the 2 billion gallon level farm income increases by $153 million. This is the net impact of a $407 million increase in grain prices and output less a $246 million increase in input costs and a drop of $57 million in federal payments to the farm. Livestock producers net income gains as a result of lower protein costs.

At the 5 billion gallon level the net impact on farm income is an increase of $1.6 billion. The impact on farm deficiency payments is a reduction of $0.9 billion.

Estimating the Economic Impacts of an Ethanol Plant. Indiana Department of Commerce. April 1992.

This study looked at the impacts of a single large corn wet milling plant. The plant had an annual output of $132.8 million and the total output impact was calculated at $449.6 million, $90.8 million in earnings and 4131 jobs. State revenues were forecast to increase by $13.5 million and local revenues by $100,000 to $3 million.

The expenditure of $117 million during construction would have a total economic impact of $418 million, create 5604 man-years of employment and increase state revenue by $20 million.

Benefits to Illinois in Developing and Utilizing Ethanol Fuels. March 1992.

This review of the Illinois ethanol industry found that over $1 billion has been invested by the industry in the state. 800 plant jobs and 4000 additional jobs in service related industries have been created. For every 100 million bushels of corn processed 2250 new rural jobs are created.

It was reported that national corn prices increase by 5 cents per bushel for every 100 million bushels of demand created. Illinois demand alone was forecast to be responsible for 8 to 10 cents of the national corn price.

Alcohol Fuels: Impacts from Increased Use of Ethanol Blended Fuels. US GAO. July 1990.

This study used the Wharton Econometric Forecasting Association model of US agriculture to estimate the impact of doubling of ethanol production to 2.2 billion gallons and a tripling over an 8-year period.

The model indicated that corn prices would increase by 32 cents per bushel under the high scenario and 19 cents per bushel in the low scenario. The overall farm income would increase by $415 million ($814 million higher prices and $399 million higher expenditures). The consumer price index would increase by 0.1 percent.

The higher farm incomes would decrease the federal deficiency payments by $900 million in the low growth scenario and $1.4 billion per year in the high growth scenario. The government fuel tax revenues would decline by $400 million in the low growth scenario and $813 million in the high growth scenario. The net impact on the federal government resulting from the ethanol program would be a savings of between $499 million and $608 million per year.

8.2 Canadian Ethanol Studies

Ethanol Fuel Study. Sypher:Mueller International Inc. Prepared for Imperial Oil. July 1999.

The objective of this study was to provide a review of ethanol and gasoline with a focus on a number of issues including economic and social impacts. The review was to be based on analysis contained existing literature sources.

The economic and social impact section quantified the potential lost government income from a 50% market penetration of 10% ethanol blends in Canada and the additional cost to consumers caused by reduced fuel economy. There was some analysis of the groups that benefit and groups that are disadvantaged by re-allocating monetary resources through ethanol tax incentives.

The calculations of foregone government tax revenues did not adjust for the lower energy content of ethanol even though for the section on direct consumer impact the extra quantity of fuel consumed was calculated. Using the report's own data, they seem to have overestimated the negative impact on tax revenue by $137 million dollars. Taking the lower energy contact of ethanol into consideration (requiring more litres of fuel to be sold and taxed), the lost tax revenue would be calculated as $163 million (not as $300 million).

The extra cost to consumers was calculated to be $300 million per year from 3% poorer fuel economy caused by the 10% ethanol blend. There was no discussion of fuel economy variances between gasolines from different refineries. In Alberta alone the variation in energy content among refineries is more than 7%. Gasoline fuel economy has not been the only consideration for refiners in the past when they have chosen refinery configurations nor is it the only measure that consumers consider as evidenced by the market share of the refiner with the low energy content gasoline in Alberta.

The discussion of groups benefiting and being disadvantaged by ethanol tax incentives draws on two of the US studies identified in the previous section, the Minnesota study and the 1997 GAO study. The Sypher study concludes that corn and soybean prices would rise, as would meat prices caused by Ontario corn supplying the ethanol for 50% of Canada's gasoline. This conclusion is not the same as the GAO referred to in the discussion. No attempt was made to determine the impact of higher agricultural prices on government revenues. The report concludes that at current ethanol production rates the farmers receive no benefit but at higher production rates the farmers would benefit at the expense of the general public.

Socio-Economic Impacts of the Pound-Maker Feedlot/Ethanol Complex. Stabler, J.C., Brown, W.J., Olfert, M.R. September 1993.

The focus of this study was on the socio-economic impacts of the Pound Maker operation on the farms and rural communities within 60 km of Lanigan, SK. The economics of ethanol production itself were not to be studied and no proprietary cost of production information was to be published. The report considers the combined costs and benefits of ethanol and cattle production. This limits the value of the report to its specific scope and context.

The direct impact of the operation on the agricultural economy included the costs and benefits associated with the crop production, manure utilization and the costs to government. Some of the findings include slightly higher grain prices were paid by the facility than local elevators, there were reduced grain handling costs for farmers and there were positive effects from the spreading of manure in terms of reduced fertilizer costs and higher yields.

Farm profitability was considerably higher over both a five-year period and a fifteen-year period with farmers who had more involvement with the Pound Maker operation.

The economic multipliers developed related to the impact on the local economy, not the provincial or Canadian economies. They are lower multipliers applied in other studies. The local employment multiplier is 1.39 and the local income multiplier is 1.32.

Kent Ethanol Feasibility Study. Chatham Ethanol Consortium. April 1993.

The primary focus of this study was to determine the financial feasibility of an ethanol plant in Kent County. This study touched on some socio-economic elements. The benefits from a plant were described as increased farm revenues, agricultural market diversification, reduction in government farm support, the potential of new types of crops on less productive lands, a better air environment, and sustainable fuel development. Since the actual size of a plant had not yet been determined the study did not attempt to quantify the benefits from the plant development or from secondary development.

An Assessment of the Costs and Benefits of an Ethanol Industry in Alberta. Touche Ross, 1988.

This report reviewed an analysis undertaken by the Government of Alberta and refined the analysis based on additional information the consultants obtained. The report concluded that an incentive level of 29 cents per litre would be required to get the gasoline industry interested in ethanol. It was assumed that ethanol plants would process barley and that a number of small 10 million litre per year plants would be constructed. The study identified a number of Alberta-specific economic multipliers for ethanol plants.

The study found that there would be a net positive impact on the Alberta economy of $19.6 million per year from the production and use of 130 million litres per year of ethanol. This impact was in the context of about $200 million worth of economic activity (positive and negative) and within the level of detail available, the consultants were not able to assign a 100% probability of a positive economic flow.

A number of key issues were identified including the impact on barley prices, incremental grain production requirements, use of DDG in the cattle feeding industry, revenue gains to the agricultural sector, impact on oil producers, refiners and marketers. The consultants concluded that there would be a small impact on grain prices and that some of the grain required for ethanol production would be new production and some would be a reallocation of exports. Very little credit was given to DDG as a protein source. It was assumed to be used as a source of energy for the cattle. It was concluded that displacement of crude oil processed in Alberta was not an issue as the oil would be absorbed by the export market. There would be some costs to the refiners to incorporate ethanol into the product mix. These were estimated to be 1.5 cents per litre of ethanol.

The major differences to the current study are the use of wheat as a feedstock for ethanol production, a lower level of Alberta support required for the ethanol industry and a better understanding of the feed value of DDG. Simply reducing the cost to the Alberta Treasury from the 29 cents per litre to 6 cents per litre (the gasoline energy equivalent value of the provincial fuel tax exemption) dramatically changes the results. The direct impact changes from a cost $12.3 million to a benefit of $18.2 million. By including the spin-off benefits the net economic impact on the province increases from $19.6 million benefit to $89.7 million.

8.3 BIODIESEL

There have been a few socio-economic studies of a biodiesel industry in the United States. Several of these are summarized below. These studies and papers have tried to quantify some of the economic and social benefits of the commercialization of biodiesel in the US. These benefits are measured on a lifecycle basis as well as on a direct cost basis. The economic benefits of using biodiesel are shown to accrue to farmers, biodiesel manufacturers, local communities, and end users.

Macro Economic Development Benefits From the Biofuels Industry. Donald Van Dyne. 1998

More jobs and increased personal income in rural communities are two of the many benefits of producing ethanol and biodiesel from agricultural feedstocks. These benefits can help reduce petroleum imports while also providing cleaner burning fuels and reduced air pollution. Other benefits include additional and more diversified markets for both starch-based and oilseed-based crops that can help production agriculture be more competitive, both locally and in the world economy. In addition to these benefits, investment in production plants also provides an increased tax base to help support local governments, schools and other public services. This happens because more money remains in the local rural communities and less is used to import petroleum.

The macroeconomic benefits of producing ethanol and biodiesel will vary by location, but will be beneficial to all areas in which they occur. This paper will provide estimates of those benefits for various locations in the U.S. for both ethanol and biodiesel. Some of the estimates are for plants that might be constructed in Missouri while others provide estimated impacts that have actually been measured in communities where plants are currently operating.

Another important macroeconomic factor is the identification of other processing plants or businesses that might locate near an ethanol or biodiesel plant. Likely candidates would be plants that would use co-products the fuel plants as inputs into their production processes. These additional plants also would be important for rural communities because they would provide additional businesses, thus additional jobs, more personal income and an increased tax base. Collectively, these efforts can help agriculture and rural communities more fully use their rural resources on a long-term sustainable basis.

Industrial Uses Agricultural Materials/Situation and Outlook Report; Economic Research Service, U. S. Department of Agriculture; Washington D.C.; November 1996

A 1996 economic study published by the USDA Office on Energy predicted that a modest, sustained annual market for biodiesel of 100 million gallons in the US would contribute approximately seven cents to the price of each bushel of soybeans produced in the US. Based on last years harvested soybean crop, that would result in more than $168 million directly attributable to the use of biodiesel.

Food and Agricultural Policy Research Institute: Increased Soybean Oil Demand, Its Effects on the Soybean and Corn Industries: University of Missouri /Columbia, CNFAP; April 1994

A 1994 economic study conducted by the Food and Agricultural Policy Research Institute predicted that a sustained national market for 70 million gallons of biodiesel annually could return up to $225 million to soybean farmers in the form of higher or sustained prices for soybeans.

Biodiesel: Potential Economic Benefits to Iowa and Iowa Soybean Producers-, Hayes D.J.; Center for Agricultural and Rural Development; Iowa State University; September 1995

A 1995 study conducted by Iowa State University looked at the possible economic benefits to the State of Iowa from the construction and operation of a moderate sized biodiesel facility within the state. The ISU study concluded that the total additional incremental cost of operating the entire Iowa state fleet (diesel portion) on B20 would be more than offset by the predicted increase in tax revenues realized by the construction and operation of a 5 million gallon a year biodiesel facility within the state of Iowa that utilized locally grown soybeans as a feedstock.

Economic impacts of Biodiesel Use in a Midwestern State Vehicle Fleet; Van Dyne D.L and Weber J.A.; Third Annual Conference on Liquid fuels and Industrial Products from Renewable Resources/Bioenergy '96; Nashville, TN; September 1996

A 1996 study conducted by the University of Missouri also looked at the possible economic benefits to the State of Missouri from the construction and operation of a biodiesel facility in Missouri. The UM study also concluded that the total additional incremental cost of operating the entire Missouri state fleet (diesel portion) on B20 would be more than offset by the predicted increase in tax revenues realized by the construction and operation of a 5 million gallon a year biodiesel facility within the state of Iowa that utilized locally grown soybeans as a feedstock. The UM study also predicted that if B20 was designated as an EPAct alternative fuel, that the State of Missouri would realize additional cost savings related to nominal incremental vehicle and infrastructure costs to utilize B20 vehicles as a compliance tool for Missouri's requirements under EPAct.

Lifecycle Costs of Alternative Fuels: Is Biodiesel Cost Competitive for Urban Buses; Ahouissoussi N. B. and Wetstein M.E.; Industrial Uses Agricultural Materials/Situation and Outlook Report; Economic Research Service, U.S. Department of Agriculture; Washington D.C.; November 1995

A 1995 USDA economic evaluation of the total operational and capital costs of biodiesel blended fuels and other fuels, such as diesel, methanol and natural gas, in urban bus fleets demonstrated that blended biodiesel fuels, such as B20, are cost effective fuels for fleets compared to other alternative fuels that require additional infrastructure, maintenance and labour costs to utilize.

The Feasibility of Producing Biodiesel in the United States Using a Community Based Facility; Industrial Uses Agricultural Materials/Situation and Outlook Report*;* Weber J.A.; Economic Research Service, U.S. Department of Agriculture; Washington D.C.; December 1993.

Biodiesel and B20 support local economic development by displacing the use of imported petroleum. A 1993 USDA study demonstrated that a modest biodiesel production facility, with as little as one million gallons of production annually, can profitable be added to existing soybean processing facilities to create new jobs as well as value added biodiesel from locally produced soybeans.

9. STAKEHOLDERS

The importance of stakeholders, project promoters and commercial companies in alternative fuels implementation cannot be underestimated. The stakeholders include farmers and farm organizations, ethanol producers, oil refiners and marketers, consumers, environmental groups and governments. The stakeholders often have conflicting views on the issues and the relative strengths of the various groups can have a significant impact on the development of projects.

In this section the views of the various stakeholder groups interested in biofuels is documented.

9.1 AGRICULTURAL PRODUCERS AND ORGANIZATIONS

Agricultural producers in North America suffer from the ability to produce more products than the market can accept. This is partly a result of increasing productivity and partly from reduced export demand for the products. High grain stocks lead to lower product prices and lower farm incomes. In order to maximize farm income producers have a tendency to produce as much grain as possible, which in turn puts further pressure on prices. This cycle is only interrupted by lower production caused by weather disturbances. In both Canada and the United States governments have moved to limit their direct involvement in supply management over the past several years which has not helped the supply and demand balance.

The production of ethanol from cereal grains creates a domestic market for agricultural products that is valued by farmers. In both Canada and the United States the corn growers associations have been strong vocal supporters of the ethanol industry. In both countries these organizations have been instrumental in the establishment and extension of tax incentives for ethanol production. The ability of the ethanol industry to create additional demand for grain has probably been overstated in most of the socio-economic assessments identified in section 8 as the impact of distillers dried grains on corn demand for animal feed has not been considered in all studies.

The US National Corn Growers Association (NCGA) promotes the following benefits of ethanol:

Ethanol provides energy security. The United States currently imports more than 50 percent of its domestic petroleum consumption - and about 80 percent of the world's proven oil reserves are in the perennially unstable Middle East. Plus, the planet has only a finite supply of fossil fuels. But ethanol is a home-grown resource made from readily replaceable agricultural feedstocks such as corn.

Ethanol offers substantial environmental benefits. Ethanol contains 35 percent oxygen, which makes gasoline burn more cleanly. That's why the Clean Air Act requires the use of oxygenated gasoline to improve air quality in the nation's most polluted cities. But unlike the petroleum-based oxygenate MTBE, which is fouling drinking water supplies from Maine to California and posing substantial public health risks, ethanol is non-toxic and biodegradable.

Ethanol is affordable and abundant. According to the Renewable Fuels Association, ethanol was selling at a net cost of just 71 cents per gallon in June, compared to the $1.24 wholesale price for a gallon of gasoline. And ethanol supplies are the most plentiful in 20 years. The ethanol industry has broken monthly production records every month this year and is poised to set an all-time record for annual production.

Ethanol is good for farmers and rural America. Ethanol is the third-largest market for U.S. corn (after livestock feed and exports), currently consuming nearly 600 million bushels per year. This demand boosts farm income by about $3 billion annually. In addition, the production of value-added ethanol has sparked new capital investment and economic development in rural communities across America. Nearly one million farmers are owner-investors in co-operative, local ethanol production facilities.

The NCGA official policy paper on ethanol is dated March 2000 and has the following highlights:

- *Work with Congress, the administration and other regulatory officials to ensure that ethanol's environmental benefits are fully and fairly considered in Phase II of the federal reformulated gasoline program and Phase III of California RFG.*
- *NCGA will work with all partners in the ethanol industry to create a unified strategy to expand ethanol usage and production.*
- *NCGA will oppose legislation that only eliminates the oxygen requirement in federal or California reformulated gasoline. NCGA also opposes any policy which allows environmental backsliding.*
- *Support legislation to restrict or eliminate the use of MTBE as a gasoline additive because of its negative effects on water quality, while taking steps to guarantee a role for ethanol as the replacement oxygenate.*
- *Support policy to restrict or eliminate the use of MTBE as a gasoline additive because of its negative effects on water quality, while taking steps to guarantee a role for ethanol as the replacement oxygenate.*
- *Support implementation of a domestic energy policy that expands the use of renewable fuels, such as ethanol, by supporting favorable tax incentives.*
- *Support the utilization of domestically produced renewable fuels as part of the clean air strategy.*
- *Promote the expanded use of ethanol.*
- *Promote the expanded use of ethanol through a national oxygenate standard of 2.7% oxygen for gasoline fuel.*
- *Support tax reform that would allow the small ethanol producer credit to be passed through to the farmer-member of co-operatives.*
- *Support the Iowa fuel quality standard.*
- *Encourage NCGA to keep in mind the competitive balance between dry mill and wet mill production as they evaluate ethanol options, and oppose any program that would jeopardize expansion of the ethanol industry.*

In Canada the Ontario Corn Growers Association highlights the following benefits of ethanol;

- Biological renewability. Ethanol is made from growing crops, not fossil energy sources. The sun is the source of most energy used to make fuel ethanol.
- Cleaner environment. When ethanol is used as an automotive fuel, either by itself or in an ethanol-gasoline blend, the result is less carbon monoxide, lower emissions of hydrocarbons into the air, and less dependence on toxic compounds used to increase the octane level of automotive fuels.
- Cleaner burning engines, less carbon build-up.
- Lower net carbon dioxide emissions caused by the combustion of automotive fuels, These means less potential for global warming.
- Less dependence on imported light crude oil used, increasingly, for gasoline production in Canada.
- Expanded market opportunity for Canadian farmers, without hampering Canadian food production capabilities.
- Economic opportunities for rural Canada.

Similar views on ethanol are expressed by other farm organizations in both countries. In addition oilseed producer organizations such as the United Soybean Board, American Soybean Association, Ontario Soybean Growers Marketing Board view the opportunity of biodiesel in the same light.

9.2 ETHANOL PRODUCERS

There are approximately 60 fuel ethanol plants in North America in operation. The plants are owned by a combination of co-operatives, private companies and public companies. The owners range from farmers to agricultural processors to energy companies to entrepreneurs. The plants range in size from 4 million litres per year to over 1 billion litres per year. Some plants are stand alone ethanol facilities while others are integrated into other operations. The feedstocks range from wastes from pulp and paper mills to corn and wheat. It is a very diverse group of organizations with some different views. Almost all are driven by a desire to have a profitable enterprise and many share a vision of producing renewable energy that can lead to a cleaner environment.

The vast majority of plants are agriculturally oriented and process corn as the feedstock. One company, High Plains Corporation, is a publicly traded company with essentially all of its assets involved in ethanol production. It provides financial statements that can be used to judge the profitability of the industry. The other public companies have substantial assets other than ethanol plants and thus do not generally provide segregated financial information. Private companies and co-operatives only provide financial data to their shareholders.

High Plains is the seventh largest U.S. ethanol producers. It operates three state-of-the-art facilities in Kansas, Nebraska and New Mexico. They have announced plans to sell the New Mexico operation. The plants convert grain into ethanol--both fuel-grade and industrial-grade and produce dried distiller's grain and solubles, which is marketed as livestock feed. In addition, they capture and market carbon dioxide gas. The products are sold nationally and internationally. High Plains goal is to provide a vital product, ethanol, that improves the quality of life, cleans the air, aids the American farmer and decreases the dependence on foreign oil. Key financial performance data is shown in Table 9-1.

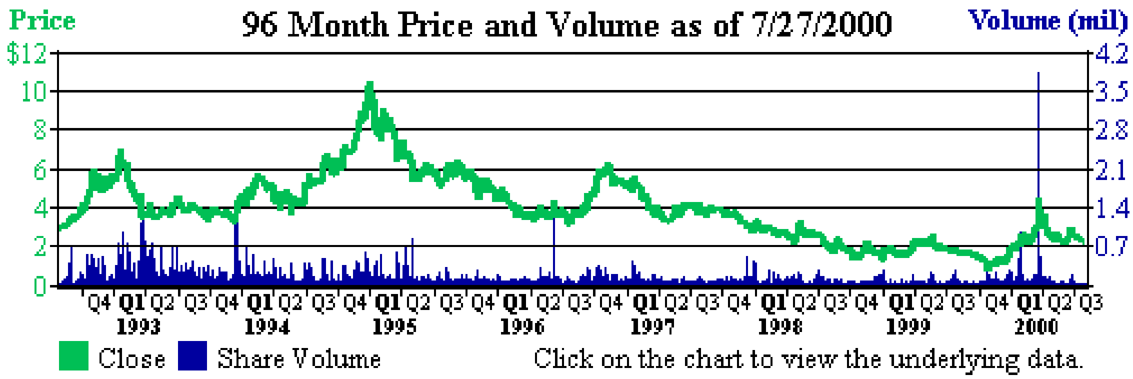
Table 9-1 High Plains Corporation Financial Data

Year	Sales ($ 1000's)	Earnings ($ 1000's)	Return on Assets
1995	52,769	6,072	9.0 %
1996	87,925	11,821	15.7%
1997	63,122	1,733	2.2%
1998	84,864	(3,593)	-4.3%
1999	96,730	535	0.7%
2000	108,531	~2,000[16]	

The company has not been highly profitable the past several years and this is reflected in its share price as shown in Figure 9-1.

[16] The company wrote down some assets in the year. The value shown is an approximation of earnings without the asset writedowns.

Figure 9-1 High Plains Share Price



Ethanol cost and selling price data shown in Table 3-16 indicated that the ethanol industry was only marginally profitable over the past five years. The High Plains data confirms that assessment.

The ethanol industry in North America is supported b the Renewable Fuels Association and the Canadian Renewable Fuels Association. Both organizations work effectively at promoting the industry particularly with governments.

9.3 OIL INDUSTRY

The oil industry in North America is large and diverse. There are a number of organizations that represent all or parts of the industry. Individual players within the industry can also take positions that are divergent from industry positions. Some of these views are presented below.

API is the major national trade association representing the entire petroleum industry: exploration and production, transportation, refining, and marketing. It has headquarters in Washington, D.C., and petroleum councils in 33 states, it is a forum for all parts of the oil and natural gas industry to pursue priority public policy objectives and advance the interests of the industry.

API speaks for the petroleum industry before Congress, state legislatures, the executive branch of government, and the news media. It negotiates with regulatory agencies and represents the industry in legal proceedings. It participates in coalitions that help shape public policy on issues such as global climate change, access and alternative fuels. And it strives to enhance credibility on the environmental, health and safety issues that are central to the public's perception of the industry and its products.

The API policy on alternative fuels is defined below (API, 1998);

Many federal, state and local laws and regulations subsidize and/or mandate use of alternative fuels, such as electricity, methanol, ethanol, natural gas, propane and hydrogen. Such measures are unnecessary and often counterproductive.

The economy and consumers are best served when all fuels openly compete, on a level playing field, without advantage of mandates or subsidies. People can then buy fuels solely on the basis of price and performance. This minimizes costs for families, businesses and the economy, which, in turn, strengthens competitiveness, living standards and job growth.

Proponents of subsidies and mandates say that they're needed to improve the environment, enhance energy security, spur economic development and replace dwindling supplies of oil. However, subsidies and mandates for alternatives, which are usually more expensive than conventional petroleum fuels, raise costs and reduce economic well-being. In addition, they have *little impact on the environment, produce limited energy security benefits, and aren't justified by the fact that oil supplies are finite.*

Annual federal and state subsidies for alternatives easily exceed $1 billion -- a number that should increase several-fold in the years ahead as existing programs are fully implemented.

Examples of federal laws that promote alternatives through subsidies or mandates include the Energy Policy Act of 1992 (which requires alternative fuel vehicles in fleets and provides tax breaks for people who buy these vehicles); the Intermodal Surface Transportation Efficiency Act of 1991 (which authorizes grants for purchasing alternative fuel vehicles and for building refuelling stations); and the Alternative Motor Fuels Act of 1988 (which allows automakers to sell more large, higher-profit conventional cars with poorer fuel economy if they also sell alternative fuel vehicles).

Many states also have laws or regulations that promote alternatives. The best example is California's mandate to force sale of electric vehicles beginning in 2003 (although California took steps to alter regulations that would have imposed such a mandate in earlier years).

There are better approaches to achieve the ostensible goals of energy subsidies and mandates.

Clean Air. According to the U.S. Environmental Protection Agency, air quality is improving, thanks largely to advances in petroleum fuels and automobile technology. The most efficient way to ensure further progress is for government to set emissions performance standards for businesses to meet -- not tell them how to reduce emissions by mandating or subsidizing certain fuels. Performance standards give businesses the flexibility to reduce pollution the most sensible, affordable way possible. That's better for consumers.

Reduced Dependence on Oil Imports. Increased use of alternatives could reduce oil imports some, but the cost of replacing oil with expensive alternatives would be high. A better way to reduce imports is to develop more U.S. oil resources. Also, it's important not to exaggerate the danger of dependence on imported oil (on which Japan and many European nations rely far more heavily than the United States). Oil producers and consumers around the world have a great stake in maintaining the free flow of oil. Moreover, the United States has a Strategic Petroleum Reserve with hundreds of millions of barrels of oil that could be drawn upon during an oil disruption, should one occur.

Adequate Energy Supplies. Oil supplies are finite, but government policies that force consumers to subsidize alternative fuels don't make sense. Oil is now in ample supply. According to the U.S. Geological Survey, proved and probable reserves can sustain world oil consumption for 63 to 95 years at current rates. And that doesn't count unconventional sources of oil, such as oil from shale and tar sands, which, though expensive to produce, could provide supplies for several more centuries. Moreover, the market will begin to provide substitutes for oil when, probably decades from now, the costs of producing it rise sufficiently to make alternatives economically viable. So oil will probably never run out, and government sponsorship of alternatives is completely unnecessary.

Notwithstanding the API position many of its refining/marketing members do use ethanol in their operations.

The Canadian Petroleum Products Institute (CPPI) is an association of Canadian companies involved in the refining, distribution, and/or marketing of petroleum products. Since its creation in 1989, the Institute has represented the views of its membership on a multitude of business, environmental, health and safety issues.

The Institute continues to work on behalf of its members on key activities such as: establishing environmental policies; establishing working relationships with governments to develop public policy on issues of common interest; developing guidelines for the safe handling of petroleum products; and providing information about our industry to the public. Several member companies do use ethanol in their refining and marketing operations and some companies are quite vocal in their opposition to the use of ethanol.

The CPPI does not have an official public position on ethanol production and use in Canada. They have actively participated in the public debate on the role of governments to promote ethanol production and use in Canada (Levy). The issues that the CPPI has raised fall into six categories and are summarized below;

1. Refinery and Terminal Considerations.
    - Volatility control of the ethanol blend raises issues for management of butane within the refinery.
    - There are other sources of octane enhancers available.
    - The gasoline to distillate ratios can be upset with ethanol addition.
    - Ethanol use can negatively impact on refinery throughputs.
    - Ethanol blends can not be pipelined to remote terminals thus increasing distribution costs.
    - Special precautions would be necessary to prepare the system for ethanol use.

2. Fuel Quality/Vehicle Performance Considerations
    - The industry claims that ethanol blends offer poorer driveability than hydrocarbon only gasoline.
    - Fuel economy is reduced on a volumetric basis.
    - Customers may expect the product to be available across a wide region and because of different tax incentives it is not feasible to do so.

3. Economics and Trade Considerations
    - Tax exemptions represent a loss in government revenues.
    - There are additional costs to consider beyond the refinery.
    - The prices of oil and ethanol feedstocks are volatile and the viability can be threatened by low oil prices or high grain prices.
    - Ethanol use could reduce oil demand and oil exports could be affected.
    - Increased demand for feedstock may not impact prices because of the international nature of the market.
    - There may be better ways to deliver aid to the farmers.

4. Environment – Criteria Air Contaminants
    - Ethanol reduces carbon monoxide emissions but vehicle technology has also reduced emissions. Carbon monoxide emissions are not an issue for any jurisdiction in Canada.
    - NOx emissions are increased.
    - Co-mingling of ethanol blends and non-blended gasoline will increase evaporative emissions.
    - Aldehyde emissions are increased.
    - Ethanol plant emissions need to be considered.
    - Impact on ground water from leaking tanks needs to be assessed.

5. Environment – Greenhouse Gas Issues
    - Some studies have shown increases in GHG emissions from ethanol.
    - Ethanol from biomass has greater projected emissions benefits but it must be treated as theoretical since there is no commercial experience with the process.

6. Other Considerations
   - Some US retailers have had a bad experience with ethanol blends and do not offer them anymore. Canadian retailers are cautious about committing to ethanol because of this.
   - Farming practices can change which will impact future benefits.

National Petrochemical Refiners Association is a trade association that represents the refining sector. In Testimony before a US Senate committee studying MTBE and gasoline they made the following statement (Slaughter). The thrust of the statement is opposition to the mandated use of ethanol but it touches on essentially all of the points of concern traditionally raised by the oil industry over the use of ethanol.

NPRA opposes fuel mandates. Mandates eliminate competition and thus are likely to result in increased costs to consumers. They inevitably foster market protections and monopolies and often result in unanticipated side effects, such as supply curtailments and higher prices. Once in place, they are then difficult to reverse. Mandating a product signals to consumers and industry that a product is uneconomic and "can't make it on its own" without special patronage. This is often harmful to the product's reputation and adversely impacts its long-term commercial acceptability and market performance. Basically, people don't like mandates. Americans value freedom of choice. Our economy reflects that characteristic, and it has served us well. In contrast, it is a foregone conclusion that gasoline subject to an ethanol mandate will be more expensive than it would be in the absence of a mandate.

We have witnessed positive results with public policies which rely on market forces, for example, the acid rain program, but by most accounts our experiment with fuel mandates for RFG oxygenates and alternative fuels have had unsatisfactory results. Given widespread dissatisfaction with the current oxygenate mandate, proponents of continued interference with market forces in fuel policies bear a heavy burden of persuasion. We do not believe that the advocates of a new ethanol mandate under the Clean Air Act have come anywhere close to making their case.

Ethanol has a bright future as a gasoline blendstock. Why risk the negative consequences of a mandate? If MTBE use is constrained, ethanol is one way refiners can provide reliable supplies of gasoline while meeting consumers' demands for fuel performance. Studies by the U.S. Department of Energy and the California Energy Commission predict significant ethanol growth in the Northeast and California, respectively, under an MTBE phase-out without a mandate. Northeast ethanol demand is estimated to exceed 550 million gallons per year if there is withdrawal of MTBE from the market while ethanol demand in California is estimated to reach 828 million gallons. The total annual ethanol demand increase for these two regions would be almost 1.4 billion gallons--or just slightly less than a doubling of today's 1.5 billion gallon usage.

In addition, the ongoing reduction of sulphur in gasoline will lead to a significant increase in ethanol use. Many refiners will give serious consideration to ethanol as a means of replacing octane lost when sulphur is reduced. Absent a mandate, the projected increase in ethanol use will take place where it makes the most economic sense to use it. Much will depend on the price of ethanol in response to such an increase in demand. However, with total U.S. demand for ethanol in 2006 estimated possibly to double today's figure, it is clear that there should be substantial growth in ethanol use even if some demand erodes as prices rise.

The impact of an extensive, national ethanol mandate on the environment is unknown. The EPA Blue Ribbon Panel pointed out "Although ethanol is likely to biodegrade rapidly in groundwater, because ethanol is infinitely soluble in water, much more ethanol will be dissolved into water than MTBE." While the environmental track record--with respect to groundwater contamination--of using ethanol in gasoline has been good, a recent ethanol leak in the Lake Tahoe area has received considerable press and public attention. This is an indication that the environmental consequences of mandated use of this highly soluble chemical are of concern. It seems wise to *proceed with a measure of caution in an area in which the public may feel that it has been recently ill served (i.e. by the oxygenate mandate).*

Air quality impacts are possible. A recent study presented by Toyota to CARB has shown that if ethanol blended at 10% replaces MTBE blended at 11% (by volume), tailpipe NOx emissions increase significantly. Also, in non-RFG regions, ethanol benefits from an EPA waiver which allows it to be blended at a higher volatility level, thus increasing evaporative emissions. Further, if ethanol blended gasoline is mixed with gasoline not containing ethanol, the ethanol causes an increase in the volatility and the evaporative emissions of the mixture. Thus, an ethanol mandate could have significant adverse impact in areas where increased ozone (smog) producing emissions are of concern.

With regard to effects on water, experience to date with ethanol blends has been relatively benign. We do know that microbes preferentially degrade ethanol present in a spill, which will retard the rate of degradation of other components.

Given the concerns expressed about MTBE, we should be cautious about new programs that would significantly increase usage of ethanol in gasoline beyond traditional volumes. The EPA Blue Ribbon Panel recommended extensive testing of gasoline constituents before widely extending their use, based upon experience with the current oxygenate mandate.

If left to the workings of the free market, ethanol has positive attributes that will promote its use. The Blue Ribbon panel described ethanol as "An effective fuel-blending component, made from domestic grain and potentially from recycled biomass, that provides high octane, carbon monoxide emission benefits, and which appears to contribute to reduction of the use of aromatics with related toxics and other air quality benefits; can be blended to maintain low fuel volatility ..."

Reliance upon a government mandate, however, could focus attention on ethanol's problematic characteristics instead. The Blue Ribbon Panel goes on to say "[ethanol]...could raise the possibility of increased ozone precursor emissions as a result of commingling in gas tanks if ethanol is not present in a majority of fuels; [ethanol] is produced currently primarily in the Midwest, requiring enhancement of infrastructure to meet broader demand; because of high biodegradability, [ethanol] may retard biodegradation and increase movement of benzene and other hydrocarbons around leaking tanks."

An ethanol mandate will make it harder for refiners to provide cleaner fuels to consumers at acceptable prices. An ethanol mandate will hinder refiners' ability to optimize the quality and volume of cleaner-burning gasoline. This will increase refining costs, impacting both gasoline supplies and price. According to the California Energy Commission, the costs of substituting ethanol-blended gasoline in that state could increase refining costs by up to 7 cents per gallon. Without a mandate, refining costs are significantly reduced, because refiners have the flexibility to economically blend gasoline in a cost-effective way that meets octane requirements while maintaining emission performance benefits.

Distribution of ethanol blends confronts refiners, other fuel suppliers and, ultimately, consumers with special economic burdens which a national mandate would increase. Adding more ethanol to gasoline is not just a matter of investment in new ethanol production facilities. Ethanol is added to gasoline at terminals, not at the refinery. Therefore, investment is necessary at terminals not currently using ethanol for equipment to receive ethanol by rail or truck (about $300,000 per terminal) to store ethanol in a tank ($450,000 for a new tank) at the terminal and to install blending equipment ($450,000 per terminal). In addition to environmental permitting requirements, these are sizeable investment requirements for terminal operators and they should not be forced by a legislative mandate. The National Petroleum Council estimates that it ethanol blends are required at all RFG terminals outside of the Midwest, the terminal capital investment requirements would total $185 million. Total investment expenses would be higher if conventional gasoline terminals in the Southeast, Southwest and West also have to be converted for ethanol blending.

In addition, ethanol presents special logistical problems. Since alcohols like ethanol tend to adhere to water and thus separate out of an oxygenated gasoline blend, it is difficult to transport ethanol blends by pipeline. Instead, a special gasoline blendstock is made for ethanol fuels (both to ease transport and to compensate for the increase in evaporative emissions associated with ethanol's higher volatility.) The ethanol itself is shipped separately by railroad, truck or ship, and the finished gasoline is blended (using special equipment) at storage terminals near the area where it will be sold to consumers. As EIA indicates in discussing ethanol logistics and costs, "Shipments to the West Coast and elsewhere via rail have been estimated to cost an extra 14.6 to 18.7 cents a gallon for transportation."

Ethanol is already heavily subsidized by taxpayers. Ethanol has received a large federal tax subsidy since 1978. Currently, this incentive is $.54 per gallon of ethanol. The incentive is financed through diversion of moneys that would otherwise go into the Highway Trust Fund. At current ethanol usage rates, the Highway Trust Fund loses about $1 billion per year in revenues because of the reduced tax rate and diversion of some receipts to the General Fund. The only way to avoid this situation is to fund new ethanol incentives out of general revenues, which would have the negative result of assessing every taxpayer to benefit fuel ethanol. As it is, many, if not most, of those who benefit from the ethanol incentives also rely on other agricultural assistance programs for corn. As the Administration states in its most recent policy analysis: "Corn producers currently receive more in direct farm support payments than producers of any other commodity."

Proposals for a national ethanol mandate seek to make energy consumers and highway users pay even more for agriculture subsidies. Consumers already pay for corn and ethanol subsidies that are funded out of the general treasury or Highway Trust Fund. But advocates of a national ethanol mandate are proposing to take an even bigger bite out of their pocketbooks. According to the Administration, "...the potential trust fund impacts (of a national mandate), ranging between more than $0.5 billion and a little under $1 billion per year, would be on the order of 1 to 2 percent of the total fund." This means that as much as $2 billion total of revenues that would otherwise go to the Highway Trust Fund would be diverted to ethanol.

According to EIA modeling, "adding a 2 percent renewable fuels standard is projected to increase gasoline prices in the 5 cents per gallon range in 2005." As a rule of thumb, a one cent increase in gasoline prices nation-wide amounts to, in the aggregate, a $1 billion additional cost to consumers. Thus, the renewable mandate will cost gasoline consumers $5 billion more in 2005 than an alternative policy option of phasing-down MTBE usage without a mandate.

The Administration's latest paper on the renewables mandate is clear in assessing the likely beneficiaries: "With 2.5 per cent of the nation's gasoline consisting of ethanol by 2010...The price of corn would be 15 cents per bushel more in 2010 than in the absence of the standard and average 11 cents per bushel more during 2002-2010...U.S. farm income would increase by $1.4 billion in 2010, and would average $750 million more per year during 2002-2010."

Ethanol credit trading pursuant to a national mandate could create regional winners and losers. Many refineries do not produce RFG, do not blend MTBE in conventional gasoline, or do not make blendstock for ethanol blending to produce gasohol. Implementation of a national renewable mandate with averaging, banking and trading could reduce investment requirements at refineries and terminals outside of the Midwest. However, a national renewable fuel mandate would segment the oil industry into winners (those in the Midwest who can offset ethanol expenses by selling excess "credits" and losers (others who would have to purchase "credits"). Consumers who purchase gasoline would benefit or be disadvantaged depending on which category their supplier fits into. Most of the winners would be located in the Midwest, with losers disproportionately located in the Northeast and West.

An ethanol mandate will make it harder for refiners to comply with priority environmental programs. Refiners are concerned with the possibility of supply disruptions as product quality specifications are changed. A renewable mandate is the same as a product specification change *for refineries that do not currently use ethanol. Congress should not impose a renewable mandate burden on these facilities that already face significant new investment requirements for reducing sulphur in gasoline and diesel fuel. The industry is committed to current implementation of RFG 2 as it is to reducing sulphur in gasoline and diesel. The imposition of additional, wholly arbitrary requirements such as a nation-wide ethanol mandate will further stress refiners and the refining system. This means that some of the programs may not achieve the projected environmental benefits.*

"Truth in labelling" is needed to clarify, rather than confuse policy options. The intent and import of the national ethanol mandate policy option would be clearer to consumers/constituents if terms and statements made by its proponents, especially the Administration, were more reflective of the likely result. NPRA makes the following observations:

1. The "renewable fuels standard" is a national ethanol mandate and should be recognized as such. The only renewable transportation fuel likely to be used in the foreseeable future as a gasoline blendstock is ethanol. The "standard" requires its use, and is indistinguishable in intent or effect from a "mandate." Also, there is no such thing as a "flexible mandate" which was EPA's initial euphemism for this program. Like "living death" or "wakeful sleep" the words "flexible mandate" are a contradiction in terms and hence oxymoronic. Policymakers who advocate basing a significant portion of America's gasoline supply on mandatory use of an already heavily subsidized product provided by an extremely concentrated industry should say so.

2. The only likely beneficiary of the national ethanol mandate is corn-based ethanol. Proponents of the national ethanol mandate are claiming that it will provide significant benefits for ethanol from biomass other than corn. The proponents allege that imminent "technological breakthroughs" will enable non- corn-derived biomass ethanol to reap significant benefits from the mandate. It would be imprudent to rely on a significant portion of gasoline supply upon such a speculative source. But the much greater likelihood is that corn ethanol will be positioned to take all of the market for ethanol in the foreseeable future, and that cellulosic biomass will fill only the tiniest increment of any ethanol actually supplied. Once corn ethanol has occupied the additional market created by the national mandate it is hard to imagine that its producers will step aside and surrender any significant portion of that market to competing suppliers of ethanol from cellulose. The Administration's emphasis upon the positive impact of the national mandate on corn prices in its recent paper gives away the real intent behind this national mandate.

3. The existing ethanol subsidy is unlikely to be repealed. Opponents of the subsidy have been trying for two decades to eliminate it. The result is usually extension of the subsidy far into the future, and often an increase in the subsidy itself. This means that revenues intended for the Highway Trust Fund will continue to be diverted. The only alternative is to take these funds from general revenues, which has other serious drawbacks. Analyses suggesting that reduction or elimination of the subsidy is a real possibility are misleading unless they indicate that the likelihood of this happening is very remote.

Conclusions

Federal policymakers should reject the call for a national ethanol mandate. Congress and the Administration should learn from, rather than repeat, the mistakes of the past. The ethanol lobby has been trying to mandate ethanol throughout the national gasoline supply for more than ten years. The oxygen mandate that has led to current water quality concerns was supported by large agribusiness in order to guarantee an ethanol market for them. Enacting another mandate to replace the problematic current one could have much greater negative consequences, including higher gasoline costs, tighter and less reliable fuel supplies, the potential for increased smog-creating emissions and a potential to create a consumer backlash. Refineries and ethanol producers can work together better to provide America's future transportation fuels in the absence of a national ethanol mandate. That will really clear the air.

9.3.1 Positions of Individual Oil Companies

Many oil companies in North America use ethanol. In some cases they are required to oxygenate their gasoline and effectively have a choice between using ethanol or MTBE and in other cases they use ethanol voluntarily. The following statements reflect individual company positions on ethanol use.

BP Amoco

The following remarks were made by W.D. Ford, Executive Vice President, Downstream in Chicago on October 14, 1999 (Ford).

"In addition, we recognize Illinois' continued interest in ethanol use. BP Amoco plans to continue to add ethanol to all grades of reformulated gasoline sold in Chicago, including the new Phase II reformulated gasoline that will be sold at our stations on January 1, 2000.

As for future products, experience has taught us that most consumers aren't willing to pay more for cleaner fuels – so our challenge will be to provide these products at the lowest possible cost."

Conoco

The Conoco web (Conoco) site contains a page on alternative and renewable energy. It states

- Conoco sells compressed natural gas, propane, methanol and ethanol in the United States and is one of the first companies to offer U.K. motorists liquefied petroleum gas alongside gasoline pumps.
- We are monitoring the feasibility of renewable energy sources.

Sunoco (USA)

The Sunoco (Sunoco) position statement on MTBE includes the following statement on ethanol;

- For example, Sunoco is a major user of another oxygenate, ethanol. However, limited supplies and difficulties in distribution make widespread ethanol use impractical on the East Coast. Also, ethanol might not comply with governmental air requirements in certain areas of our region.

Sunoco (Canada)

The Sunoco brand in Canada is now a separate company from the US brand. They are Canada's largest marketer of ethanol gasoline blends. Their web site contains the following information about ethanol.

- All Sunoco gasoline products include ethanol at no extra cost. Environment Canada has licensed ethanol-enhanced Sunoco gasolines to use its official mark, the EcoLogo, its Environmental Choice product designation.
- In 1999 Sunoco increased the percentage of ethanol in gasoline sold at all Sunoco-branded retail sites. Ethanol-enhanced gasoline reduces carbon monoxide and greenhouse gas emissions compared with conventional gasoline. Sunoco's gasoline and car washes are certified to display Environment Canada's EcoLogo certification, which demonstrates active commitment to offering environmentally friendlier products and services.
- Ethanol is a fuel additive that reduces emissions of carbon monoxide by up to 30% and because ethanol is a natural de-icer, there's no need to spend money on gas-line antifreeze during the winter months.
- Sunoco continues to focus on and address environmental issues facing Ontario and Canada. In 1999, Sunoco introduced a new ethanol gasoline additive that reduces nitrogen oxides

(NOx) from tailpipe emissions. This initiative generated over 275 tons of NOx credits under Ontario's Pilot Emissions Reduction Trading project. Sunoco then sold the credits to Ontario Power Generation Inc. and intends to use a portion of the proceeds from the emissions trade to fund additional pollution prevention projects.

- Sunoco offers the widest choice of octane on the market, and our Ultra 94 is the highest octane available on the street. Our gasoline grades include:
  - Ultra94 (94 Octane)
  - Supreme (92 Octane)
  - Plus (89.5 Octane)
  - Regular (87 Octane)

9.4 ENVIRONMENTAL GROUPS

There are hundreds of environmental groups in North America and they have a wide range of views on many subjects. Most environmental groups are supportive of renewable fuels but a number have reservations about ethanol. The reservations are primarily focused on two issues; the higher vapour pressure of ethanol blended gasoline and the use of corn, a food ingredient, as a feedstock.

Doug Howell (Howell) of the Environmental and Energy Study Institute (EESI) mentioned both issues in a presentation at the National Conference on Ethanol Policy and Marketing in March 2000. In the United States ethanol in conventional gasoline and in the winter oxygenated fuels program has a 7 kPa vapour pressure allowance compared to non-oxygenated gasoline. The higher vapour pressure increases the evaporative emissions from vehicles in the summer. The higher emissions can lead to higher levels of ozone in the atmosphere. Environmental groups are concerned that the higher evaporative emissions outweigh the benefits of lower exhaust emissions. Howell stated that environmental groups would be much more supportive of ethanol if ethanol blended gasoline had the same vapour pressure as gasoline. This would require refiners to produce a special blendstock that has a lower vapour pressure. This is technically feasible but adds to the cost both in the refinery and in the distribution system.

The official positioning statement of the EESI on ethanol is presented below;

The Environmental and Energy Study Institute hopes to build consensus within the environmental community regarding the potential benefits of ethanol – and particularly the expanded opportunities provided by cellulosic ethanol – with a special focus on climate protection. Ethanol can also be a political bridge to broader alliances in support of climate initiatives.

Many in the environmental community have made strong statements in support of ethanol as a low-carbon fuel with large potential benefits to reduce life-cycle greenhouse gas emissions. Ethanol also reduces carbon monoxide emissions and our reliance on oil, contains no sulphur and helps to eliminate smog through its use as an oxygenate for gasoline. Cellulosic ethanol, which is produced from agricultural or wood wastes, provides even greater GHG emission reductions than corn-based ethanol, promotes rural economic revitalization and offers a solution to waste disposal problems.

However, there have been concerns about ethanol ranging from volatile organic compounds (VOCs) to corporate welfare.

The environmental groups are much more supportive of ethanol produced from biomass than ethanol produced from corn. There are several reasons for this. The first is that studies on greenhouse gas emissions have indicated that biomass ethanol with have lower greenhouse gas emissions than ethanol produced from corn. The second is the issue of food versus fuel. There is concern that there is not sufficient corn for the widespread adoption of ethanol as a transportation fuel. There is also a concern with some groups that corn farming is environmentally non-sustainable. These concerns to some degree have been addressed by the industry by changing farming practices over the past 20-30 years but the concerns still linger with some groups.

Ethanol produced from biomass and blended into gasoline such that the blend had the same vapour pressure and thus evaporative emissions as gasoline would likely find widespread support among environmental groups. That scenario is not commercially feasible at this time.

In Canada the David Suzuki Foundation is advocating a mandatory renewable energy content of 5 per cent, such as fuel ethanol, to replace some of the gasoline Canadians use.

9.5 CONSUMERS

CONSUMER ORGANIZATIONS

Consumer organizations such as the Canadian Automobile Association (CAA) represent the rights and interests of Canadian motorists. Through public awareness campaigns and government lobbying, CAA works to ensure safe and enjoyable driving for all Canadians.

The CAA *Statement of Policy*, supports measures to make cars and fuel cleaner and greener--measures such as mandatory fuel consumption standards and lower emission levels**.**

The CAA believes that despite the strides that have been made in reducing pollution from new vehicles, more can and will be done. CAA and its members are determined to forge ahead to reduce emissions. So much has already been done to make cars themselves cleaner, and the focus has now shifted to making fuels cleaner.

CAA believes one can reduce carbon dioxide emissions from cars by:

- consuming fuel more efficiently. CAA recommends proclaiming the *Motor Vehicle Fuel Consumption Standards Act* and setting made-in-Canada standards that are progressively more stringent.
- switching to lower carbon content fuels such as natural gas, which has a carbon content one-third less than conventional gasoline, or ethanol, which is made from wood waste or agricultural sources.

The American Automobile Association does not appear to have the same policy.

CONSUMER BEHAVIOUR

The success of biofuels ultimately depends on the consumers accepting and adopting the new products. The adoption of new products or innovations is a complex process and in the case of alternative fuels and alternative fuelled vehicles it is definitely not a case of “Build it and they will come”.

There have been relatively few successful introductions of alternative fuels and alternatively fuelled vehicles in North America over the past twenty years. The Canadian propane program of the early 1980’s and the use of the gasoline additives, ethanol and MTBE in the 1990’s have enjoyed the most success. There have also been programs that have failed such as low level methanol blends and M85. Other fuels such as natural gas are still being actively promoted but have yet to achieve significant market penetration. In order to better understand why some programs succeed and some fail it is important to understand the process by which innovations diffuse through society.

There are four main elements to the diffusion of innovations. There is the innovation itself, the communication of the innovation, time and the social system which is attempting to adopt the new technology. Each element is critical to the successful diffusion of innovation or technology.

The innovations that are considered here are biofuels or biofuels and vehicles in the cases of new systems. The characteristics of the technology as perceived by the potential user help to determine the rate at which the new technology is taken up.

The relative advantage of biofuels is the degree to which the fuel is perceived to be better than the gasoline or diesel fuel it replaces. The degree of advantage can be measured in economic terms but other factors such as social prestige, convenience and satisfaction a play a role in determining the perceived relative advantage. The true objective advantage is not as important as the perceived advantage. It is recognized and important to note that the expected continued improvement in gasoline vehicle technology over the study period presents a moving target for new technology and makes a relative advantage of an alternative technology more difficult to achieve and demonstrate. The relative advantage can and will change over time.

The factors than can impact on the perceived relative advantage are both objective and subjective. The objective factors include:

- Fuel cost
- Vehicle Range
- Refuelling time and convenience (converted to a cost of time)
- Vehicle cost
- Vehicle performance
- Capacity for people and cargo
- Value of a multi-fuel option

The subjective attributes that are important include:

- Fuel availability
- Fuel quality and the impact on
    - Performance
    - Reliability
- Health and safety
- Aesthetics
- Social benefits
- Emissions
- Oil dependence
- Vehicle reliability and maintenance
- Vehicle health and safety

These subjective attributes play at least as big a role in determining the perceived relative advantage of a fuel as the objective attributes. The US DOE has a model that can be used to predict market penetration of alternative fuel vehicles. The model has consistently over estimated the market penetration of alternative fuels probably due to the fact that it can not model the subjective attributes.

Successful innovations must be consistent with the existing values, past experiences, and needs of potential adopters. Technologies that require changes with the values and norms of a society take much longer to adopt. The adoption of these incompatible innovations requires the prior adoption of a new value system. In the context of fuels and vehicles a concern for the environment is a value that is slowly becoming part of society's value system but it is still a relatively small component of determining the relative advantage of a new technology.

Innovations that are easy to understand by most members of society will be adopted quicker than difficult and complex technologies. Liquid fuels that can be handled like gasoline and diesel are easier to comprehend than gaseous fuels. The new liquid fuels have attracted attention quicker and easier than a fuel like natural gas. As has been experienced with a fuel like M85 this familiarity does not insure success.

It is important for consumers to be able to try new things without making a permanent commitment. The reformulation of existing fuels has a distinct advantage over fuels that require the purchase of a new vehicle. Fuels that can be tried and experimented with reduce the uncertainty to an individual and provide the opportunity to learn about the new innovation. Innovations that are trialable generally get adopted quicker than those that are not. Fuels that are trialable would be variations of existing gasolines and diesel fuels such as low-level ethanol blends and biodiesel.

Observability is another quality that influences the rate of adoption of new technologies. The easier it is for individuals to see the results of an innovation the more likely it is that they will adopt it. Fuels are not easily observable, which partially explains the slow rate of adoption of new fuels. Most people never see or touch the gasoline or diesel fuel that they put into their vehicles. The exception may have been propane powered pickup trucks with the fuel tank clearly visible. This observability may have aided the adoption of propane as a vehicle fuel in the 1980's.

These five qualities, relative advantage, compatibility, trialability, observability and complexity have been identified by past diffusion research as the most important characteristics of innovations that determine their rate of adoption.

Communication is the process by which participants create and share information with one another in order to reach a mutual understanding. The essence of the diffusion process is the communication of a new idea from one individual to another. A communication channel is the means by which messages get from one participant to another. Mass media channels are effective at creating awareness of a new idea but interpersonal channels involving face to face exchanges are more effective at persuading individuals to accept a new idea.

Research into the diffusion process has indicated that most individuals do not evaluate an innovation on the basis of scientific studies of its consequences. Instead, most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals like themselves who have previously adopted the innovation. This dependence on the experience of near peers suggests that the heart of the diffusion to potential adopters consists of modelling and imitation of those who have adopted previously. So, diffusion is a very social process.

One of the problems that a number of alternative fuels have experienced is with the face to face exposure between knowledgeable people and potential customers. In the fuel industry the lowest paid and highest turnover individuals (front-end attendants) are the ones with the most customer interactions. It is very difficult to maintain knowledgeable and effective sales force at the primary point of customer contact. Similarly with the sale of new vehicles the sales force is an independent entity distinct from the manufacturer of the vehicle. This group's goal and objectives are not always aligned with the sale of new technology vehicles, a sale that will probably require more time and effort and potentially has a higher risk of customer dissatisfaction due the limited trialability of the new technology.

Effective communications also has a financial component. Mass media awareness and interpersonal communications are expensive to implement but effective programs can be developed given sufficient financial resources.

Time is a third element in the diffusion process. The time dimension is involved in diffusion in three ways:

1. in the innovation decision process by which an individual passes from first knowledge of an innovation through its adoption or rejection,
2. in the relative earliness/lateness with which an innovation is adopted,
3. in the innovations rate of adoption in a system.

The innovation decision process is the process through which an individual passes from first knowledge of innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision. There are five main steps in the innovation decision process:

- knowledge
- persuasion
- decision
- implementation and
- confirmation.

These five steps usually occur in time ordered sequence. There can be exceptions to the order such as when the decision that is taken before persuasion.

Not all individuals proceed through the decision process at the same rate. An individual can be more or less innovative that another member of the social system. Individuals can be ranked in order of their innovativeness. The five classes of innovators, include:

- innovators
- early adopters
- early majority
- late majority and
- laggards.

Individuals within each class of innovators will have much in common. It is important to note that each class of innovator will rank the relative advantages of attributes differently, to the relative importance of mass media communications vs. interpersonal communication and whether they are active or passive information seekers.

The social system is the fourth element of the diffusion process. The members of the social system are engaged in joint problem solving to accomplish a common goal. The members may be individuals, informal groups, or organizations. The most innovative members are not always influential in the decision making process as they often have low credibility due to their willingness to try all new things. Opinion leaders and change agents, people who are able to persuade others to change are the most influential members in the social system. New technologies will not be adopted without these members.

The social system has another important influence on the diffusion of new ideas. Innovations can be accepted or rejected by one individual or by the entire system by a collective or authoritative decision. The individual optional innovative decisions are made independent of other members. These decisions are the classical means by which new ideas have spread through society. Collective decisions are made by consensus of the members of a group. The establishment of car pools would be an example of a collective decision. Authority decisions are those made by a few individuals who have the power, status, or technical expertise to make decisions for all members of the society. Individuals have little or no influence on the decision. Relevant examples would be the establishment of new standards for fuels or vehicle fuel economy, or the use of biodiesel blends in a companies diesel fuel products. The fourth type of decision is contingent decision; this is a sequential decision of two or more of the other types of decisions. This type can be made only after another decision has been made. They tend to have long implementation times. They are also typical of the type found with alternative fuels that require both new fuels and vehicles to be introduced at the same time.

The biofuels ethanol and biodiesel are rated on the important attributes and elements that contribute to successful new product innovations in the following table.

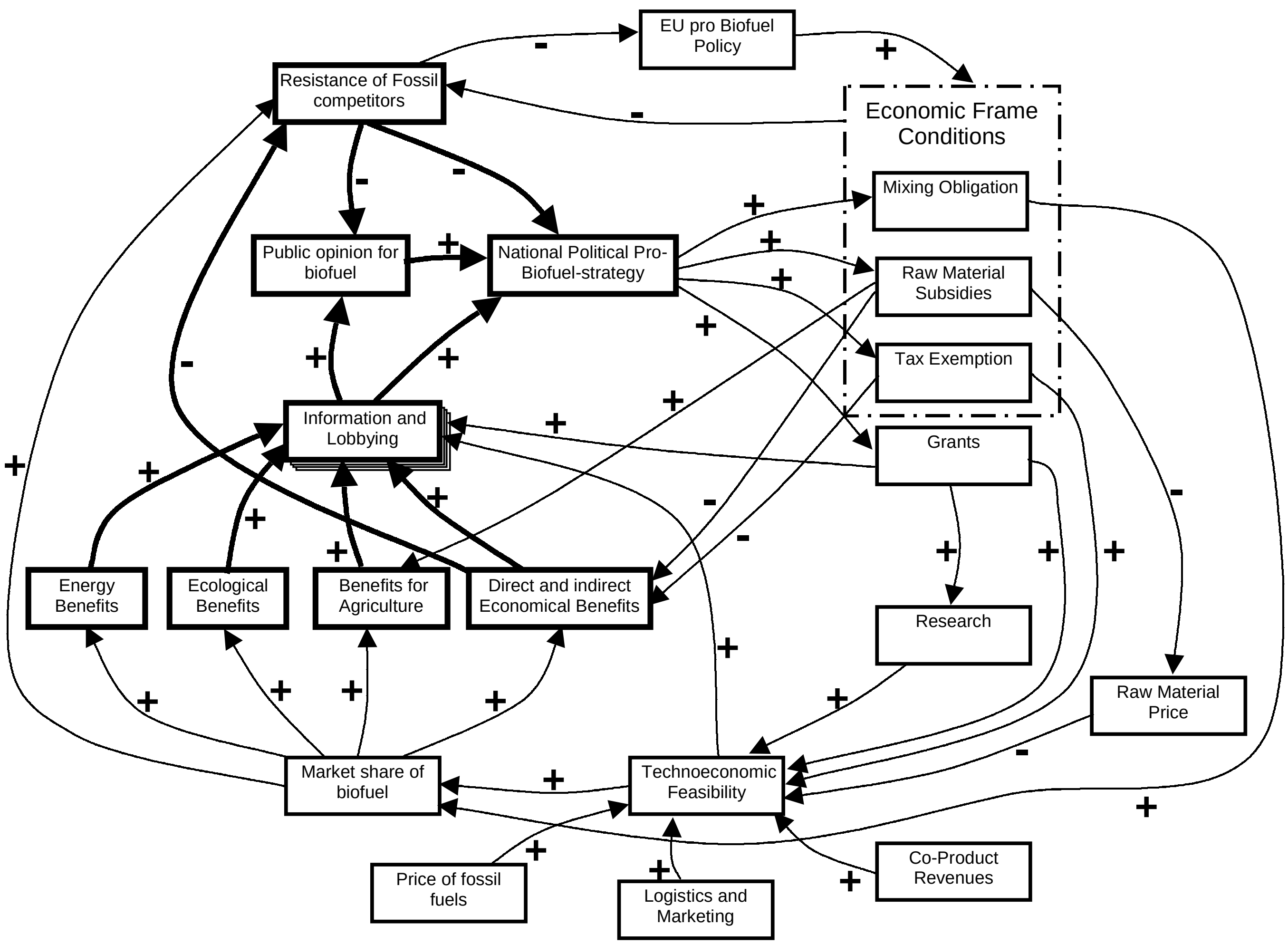
Table 9-2 Biofuel Attributes

	E10 Blends	E85 Dedicated Vehicles	Biodiesel
Relative advantage:			
performance	+	+	+
cost	-	-	-
environment	+	+	+
convenience	0	0	0
prestige	0	0	0
Compatibility	0	-	+
Complexity	0	0	0
Trialability	+	-	+
Observability	0	0	0
Ease of Communication	+	-	+
Time	+	-	+
Decision process			
individual	+	+	+
collective	+		+
authoritative	+		+
sequential		+	

9.6 STAKEHOLDER INTERACTION

The stakeholders' positions have been discussed independently, in reality they all interact in a dynamic system. The interaction has been modeled by sYsan for their study of biodiesel in Europe. Their model is shown in Figure 9-2.

Figure 9-2 Stakeholder Interaction Model



10. OTHER FACTORS

There are some technical characteristics of ethanol and ethanol gasoline blends that impact on the distribution of ethanol blended gasolines and thus has a financial impact. The financial impact represents a potential barrier to market penetration. There are also regional economic factors for both gasoline and ethanol that impact on the use of ethanol in various parts of North America. These factors are investigated in this chapter.

10.1 ETHANOL VS. MTBE

Ethanol and Methyl tertiary-butyl ether (MTBE) are competing gasoline blending components. They have many similar characteristics but also some distinct differences.

MTBE is manufactured from methanol and isobutylene. The methanol is almost always manufactured from natural gas and the isobutylene is either a by-product of the refining process or manufactured from field butanes. MTBE facilities within a refinery tend to be small units limited by the availability of isobutylene. Stand-alone facilities that obtain the isobutylene from butane are usually larger units producing 10,000 bbls/day (584 million litres/year) or more of MTBE.

US MTBE demand was reported to be 250,000 bbls/day in 1997 (~14 billion litre/year) by the US Energy Information Administration.

MTBE began to be used as a gasoline blending component in the early 1980's. Initially it was used because of its high octane value and it was used to replace lead as an octane booster. In the 1990's with the introduction of winter Oxyfuel programs and Reformulated Gasoline in the US it was also used as a source of oxygen for gasoline.

10.1.1 Technical Characteristics

The key properties of the two components are shown in Table 10-1.

Table 10-1 Summary of Key Properties of Ethanol and MTBE

	MTBE	Ethanol
Blending Octane (R+M/2)	110	115
Blending Vapour Pressure, kPa	62	125
Oxygen Content, wt %	18.2	34.4
Water solubility, fuel in water, vol. %	4.3	100
Water solubility, water in fuel, vol. %	1.4	100
Heat of vapourization, BTU/L	228	630
Heating Value, BTU/L (lower)	24,735	20,100

Both fuels are high octane oxygenated compounds suitable for blending with gasoline. Ethanol has a slightly higher octane rating and more oxygen. The key differences are the blending vapour pressure and the water solubility.

10.2 DISTRIBUTION ISSUES

Ethanol is distributed in a system that is largely independent of the gasoline distribution system. Ethanol is normally introduced to the gasoline only at the final terminal prior to the service station. This is due in part to the smaller volumes and different distribution patterns and in part due to the technical characteristics of ethanol and ethanol blended gasoline. This separate system adds costs that are reflected in the price of ethanol.

10.2.1 Water

The issue of water and oxygenated gasoline is complex. Ethanol and MTBE have very different characteristics in the presence of water but both have significant water related issues. The low solubility of water in MTBE and MTBE blended fuels means that MTBE containing gasoline can be pipelined and exposed to small amounts of water in the process and still have a single fuel phase with limited water content. This means that no special precautions need to be taken to maintain the integrity of the fuel through the distribution system from the refinery to the retail tank. This is important since small amounts of water are often found in common carrier pipelines, terminal tanks and even service station tanks. It also means that MTBE can piggyback on the vast efficient gasoline distribution system in North America.

While there are no fuels and vehicle related issues with MTBE gasoline blends exposed to water there are concerns about MTBE contaminating ground water. MTBE use in gasoline has become a significant concern in the US over the past several years due to this issue. Many chemicals in gasoline, including MTBE, can be harmful in water. However, MTBE is highly soluble in water and if gasoline containing MTBE is spilled or leaks into the soil the MTBE travels faster and further in water than the other gasoline components. MTBE is therefore more likely to be found in ground water or drinking water than other gasoline components. The low biodegradability of MTBE combined with its distinctive odour has made MTBE use in gasoline an issue of significant public concern. The State of California moved to eliminate the use of MTBE in gasoline and an EPA recently announced its intention to phase-out MTBE from use in gasoline.

Ethanol has very different issues with water. The high solubility of water in ethanol combined with the low solubility of wet ethanol in gasoline means that excess water can cause an ethanol blended gasoline to separate into two phases, a heavy phase with water, ethanol and some gasoline and a lighter phase with gasoline, some ethanol and small amounts of water. The heavy phase is drawn from the system first either in the vehicle tank or distribution tank. This material is often not combustible in an engine since the gasoline content is too low. The maximum water content of an ethanol gasoline blend is a function of the ethanol content, the gasoline composition, and temperature. A 10% blend in a gasoline with about 35% aromatic content and at 20C with absorb about 0.5% vol. water before phase separation occurs. This is sufficient to be practical in a dry distribution system. Lower aromatic contents, lower ethanol contents and colder temperatures all result in a lower water tolerance. A 5% blend in 20% aromatic gasoline at –40C can hold about 0.2% water in a stable phase. Blends similar to this have been successfully used in Canadian winters for 20 years with very few problems.

The problems with excess water and ethanol blends are most severe when the blends are being introduced to the system for the first time. That is when water is most likely to be present and not detected. Underground tanks can be sloped the wrong way and contain water that can not be detected.

To minimize these problems ethanol is usually added at a terminal just prior to truck delivery of the blended product to the service station. This is the easiest way to keep the blended product dry and prevent any phase separation problems. Most marketers also take extra precautions when introducing ethanol blends at service stations to minimize water problems. Unfortunately this means that it is inconvenient or expensive to frequently switch between ethanol blended gasolines and ordinary gasoline. The extra precautions and the lack of flexibility are reflected in the price and market share of ethanol.

10.2.2 Vapour Pressure

While ethanol as a pure compound has a very low vapour pressure when it is added to gasoline it forms azeotropes with many of the individual components of gasoline and these result in an increase in the vapour pressure when measured in a standard procedure such as the Reid vapour Pressure test. MTBE has a vapour pressure about the same as gasoline and it behaves ideally when added to gasoline. It can thus be added to gasoline without the result blend falling outside the vapour pressure specification.

The vapour pressure of gasoline can be adjusted so that the resultant ethanol blend meets specifications. The most common means of accomplishing this is to reduce the butane content of the gasoline. Butane is a low cost, high octane component and thus low butane gasoline usually costs more. This gasoline must be kept in separate tanks from the regular gas and so distribution costs also tend to increase. The high blending vapour pressure of ethanol thus reduces the value of the ethanol if the RVP must be controlled.

The effects of this RVP issue on the refining value of ethanol were analysed for the National Renewable Energy Laboratory (MathPro). They found that the cost of reduced RVP gasoline was equal to about 1.3 cents per litre of ethanol. They also reported that others had found the costs might be as high as 2.6 cents per litre for some refineries.

10.2.3 Economic Comparison

The value of MTBE and ethanol should be similar or perhaps even slightly higher for ethanol since it has a slightly higher octane content and a higher oxygen content if gasoline blending components were valued only on their octane and oxygen contents. In the next table the historical price relationship between MTBE and ethanol is shown. Net ethanol includes the impact of the federal tax incentive.

Table 10-2 MTBE and Ethanol Pricing

Period	MTBE	Ethanol	Net Ethanol	MTBE-Ethanol
1984	25.4	41.0	25.1	0.3
1985	27.0	39.4	23.5	3.5
1986	18.0	27.8	11.9	6.1
1987	18.2	28.6	12.7	5.5
1988	22.2	28.3	12.4	9.8
1989	23.0	30.2	14.3	8.7
1990	28.8	32.3	16.4	12.4
1991	24.6	30.2	15.9	8.7
1992	23.3	32.8	18.5	4.8
1993	18.5	28.6	14.3	4.2
1994	22.2	30.2	15.9	6.3
1995	22.5	29.1	14.8	7.7
1996	21.9	36.0	21.7	0.2
1997	22.1	31.5	17.2	4.9
1998	17.1	27.8	13.5	3.6
1999	18.0	26.2	11.9	6.1

The long term average differential has been 5.8 cents per litre of ethanol. The higher distribution costs for ethanol will make up a large portion of this differential. The other factors that will contribute to this differential include the lack of flexibility of using ethanol, any perceived negatives to ethanol use in the view of the oil company and the inability to capture the octane value of the ethanol due to the blending occurring at the terminal rather than the refinery.

Andress (1999) estimates that the additional handling and logistics costs of ethanol total 2.6 cents per litre of ethanol. The value of ethanol to a refiner must reflect both the vapour pressure issue and the additional distribution costs. The 3.9 to 5.2 cents identified here as the costs of these two factors is relatively close to the long term differential between ethanol and MTBE.

10.3 Regional Economics

Throughout the report the economic comparisons have been made on the basis of national average gasoline and ethanol prices. Prices can vary from region to region and given the sensitivity of the gasoline market in North America to price the success of biofuels could be quite different in different regions.

10.3.1 Ethanol

Ethanol production is concentrated in the US Mid West as shown in Figure 2-2. This is the heart of the US Corn Belt and has the lowest feedstock costs. The cost of moving ethanol from the producers in the Mid West to markets on the coasts can be substantial. It has been estimated (Downstream Alternatives) that freight costs from the Mid west to California is in the range of 3.7 to 4.5 cents per litre. The costs are about the same moving the product by rail or barge and marine vessel. This is very similar to the gasoline price differentials between the West Coast and the Mid West (Figure 3-3).

The marketplace does not always allow the full recovery of costs. The current ethanol prices (OXY-Fuel News, August 28) in various locations across the United States are shown in Table 10-3.

Table 10-3 Ethanol Prices in the United States

Location	Ethanol Price cents per litre
Richmond, Virginia	34.7
Upstate, New York	34.7
Omaha, Nebraska	35.7
Houston, Texas	35.7
Detroit, Michigan	36.0
Chicago, Illinois	36.5
Cedar Rapids, Iowa	36.5
Minneapolis, Minnesota	36.8
Pekin, Illinois	37.3
Los Angeles, California	37.3
Seattle, Washington	37.3

It is apparent from the table that ethanol producers are not always able to recover their distribution costs. The prices of ethanol on the West Coast do not reflect the 4 cents per litre additional freight cost and ethanol prices on the East Coast and the Gulf Coast are lower than they are in the Mid West where the product is manufactured. The inability of a producer to recover additional freight costs will encourage the producer to develop markets close to the plant.

When the profitability of ethanol production is marginal, as it has been through most of the late 90's the additional distribution costs are difficult to absorb. With current (August 2000) production costs including capital of 25 cents per litre and selling prices of 35 to 37 cents per litre there is the opportunity to absorb some distribution costs. This may partially account for the high level of ethanol sales over the summer of 2000.

10.3.2 Gasoline

As shown in Figure 3-3 the gasoline price varies significantly throughout the United States. The variances are caused not only by supply and demand issues but also due to distribution costs of crude oil and refined products. Gasoline prices are lowest on the Gulf Coast and the Southeast region. They are about one cent per litre higher in the Midwest and Mid-Atlantic states, another cent higher in New England, a total of three cents higher in the Rocky Mountain states and on the West Coast, with California's different gasoline composition requirements they are a total of five cents per litre higher.

The flow of gasoline and crude oil is in the opposite direction to the flow of ethanol. Gasoline and crude oil move from the Gulf Coast into the Mid west and Mid Atlantic states by pipeline. This will mean that ethanol is more competitive in some markets than in others and encourages the use of ethanol in the Midwest markets.

10.4 E10 VERSUS E85

There are differences in the value of ethanol between its use in E10 and in E85 that are caused by ethanol's lower energy content compared to gasoline. In E10 with only about 3.5% less energy than gasoline on a volumetric basis this factor is essentially ignored by marketers and the fuel is sold at the same price as gasoline. For E85 the energy content is about 30% lower and if an allowance if made for the 5% better fuel economy that these vehicles appear to get, the net 25% reduction in energy is not likely to be able to be passed on to the customer. E85 blends must therefore be priced on an energy equivalent basis in order not to be at an economic disadvantage to gasoline. In the following table the impact of this is detailed for the Canadian province of Ontario. The table is in Canadian currency (one Can $=$0.67 US). Other jurisdictions will have similar, although not identical impacts because of small differences in taxation.

Table 10-4 Ethanol Value- E10 vs. E85 - Ontario

	Gasoline	E10	E85
Gasoline, Can cents/Litre	22	19.8	3.3
Ethanol		4.7	25.5
Federal Tax	10	9	1.5
Provincial Tax	14.7	13.2	2.2
Retail margin + GST	10	10	10
Total	56.7	56.7	42.5
Gasoline energy equivalent price	56.7	56.7	56.7
Ethanol value		47	30

In this example the E85 is priced to the customer at 75% of the gasoline price so that the cost per mile for fuel is exactly the same in the E85 vehicle as in the gasoline powered vehicle. The retailer must be able to purchase the ethanol for 30 cents per litre compared to being able to pay 47 cents per litre for ethanol sold as E10. This much lower netback for E85 is a significant barrier for the development of this market, at least when oil prices were $20/bbl or less.

The situation in the United States is similar. There is a lower federal tax rate on E85 of 2.45 cents per litre versus the gasoline tax of 4.9 cents per litre. In addition the blenders tax credit of 14.3 cents per litre of ethanol will apply provided the blender has taxable income. This may have an after tax value of 10 cents per litre. Most states tax E85 at the same volumetric rate as gasoline. A similar table is shown for a typical state below.

Table 10-5 Ethanol Value- E10 vs. E85 – United States

	Gasoline	E10	E85
Gasoline, cents/Litre	15	13.5	2.25
Ethanol, net of tax credit		2.8	7.75
Federal Tax	4.9	3.4	2.45
State Tax	5.3	5.3	5.3
Retail margin	4	4	4
Total	29.2	29.0	21.75
Gasoline energy equivalent price	29.2	29.0	29.0
Ethanol value, net of tax credit		28	9.1

Even if the blender can maximize the value of the blender tax credit of 14.3 cents per litre the value of ethanol in E85 (23.4 cents per litre) is substantially lower than it is in E10.

11. EVALUATION AND GROWTH SCENARIOS

The evaluation of ethanol and biodiesel in Canada and the United States is considered and evaluated in the context of the three phases of development that were adopted for this and the companion studies in Europe. Also considered were the two biofuels scenarios considered for the future, the modest increase of 10% over a five-year period and the more challenging goal of 5% of fuel consumption over a ten-year period.

Phase 1 of a development represents the first beginning of a concept. It is dominated by an emerging problem and the search for a solution. There may be experiments and small-scale tests performed to verify the solutions and identify the relative advantages of the solution. The benefits in terms of environmental advantages, direct and indirect economic spin-offs, the impact on agricultural issues and energy self sufficiency will be identified and communicated to the key influencers and decision makers. If the economics of the concept require financial incentives to overcome inertia in the system this phase will include significant political debate.

Phase 2 of the development is characterized by pilot plants and demonstrations. The objectives of Phase 2 are to optimize the production and logistic processes, to determine the compatibility of the new product with societies value system, to allow the innovators to try the new product and gain experience and to showcase the new innovation to potential users. The technical and economic feasibility is a key deliverable from this phase.

Phase 3 of the process is dominated by commercial activity. Many stakeholders are involved. Research and development still occur but it tends to be done by companies involved in the system. There will be a significant communications effort to encourage the early adopters first and then the majority of consumers to adopt the new product. If the economic feasibility is dependent on internalizing external costs there will be a continuing effort to keep the political decision makers informed as to the overall benefits of the activities.

In this section of the report the biofuels under consideration are characterized as to their stage of development. Fuels in Phase 3 are studied and evaluated to determine the critical success factors and lessons learned so that the feasibility of the two goals can be determined.

11.1 ETHANOL EVALUATION

Ethanol from grain in both Canada and the United States is clearly in Phase 3 of its development; i.e. it is a commercial activity. While ethanol from grain is a commercial activity it still represents a relatively small proportion of the transportation fuel market in North America. It is more successful in some areas than in others as shown in Table 2-3. Ethanol usage is analyzed to determine the critical success factors.

Ethanol from lignocellulosics is still a Phase 2 activity in North America. It is still dominated by research activities to optimize the production systems.

11.1.1 Current Ethanol Use

The approach in this section is to identify those states and those regions of Canada that have the highest market penetrations of ethanol and the highest ethanol usage and identify the critical success factors that have led to that situation. In Table 11-1 the top 15 states in market share are identified. Each of the states is then analyzed for factors that lead to that success.

Table 11-1 Top States in Ethanol Market Penetration - 1998

State	Ethanol Blended Market Share	Ethanol Used in the State	Ethanol Production Capacity in the State	RFG	Oxy Fuel
		1000 L			
Minnesota	91.73%	751,290	880,000		
Iowa	43.61%	258,725	1,555,000		
Illinois	43.42%	802,003	2,124,000	Yes	
Ohio	40.59%	801,851	0	Yes	
South Dakota	40.11%	67,998	110,000		
Colorado	35.88%	223,160	5,600		Yes
New Mexico	25.86%	99,486	In active		
Nebraska	22.90%	74,750	1,300,000		
Nevada	19.01%	52,213	0		Yes
Indiana	17.87%	214,655	320,000	Yes	
Utah	13.54%	44,071	0		Yes
Wisconsin	12.75%	122,215	0	Yes	
Washington	12.53%	123,829	29,000		Yes
North Dakota	12.22%	17,184	145,000		
Virginia	10.35%	136,515	0	Yes	

Minnesota

The State of Minnesota has a requirement that all gasoline contain 2.7% wt oxygen. The sole exception is that one tank may dispense non-oxygenated premium unleaded gasoline for use in collector vehicles, off-road vehicles, motorcycles, boats, snowmobiles or small engines. The state also has producer incentives of 5.3 cents per litre for the first 56 million litres per year for a ten-year period. Most plants in Minnesota are small (60 million litres/year) as a result of this incentive. Many of the plants are farmer owned co-ops. There are a total of 15 ethanol plants in the state.

The plants are quite profitable. It was reported (Gaffaney) that an average of five plants in 1998 had an after tax profit of $3.1 million dollars and that the average equity in each plant was $12 million. This represents a 25.8% return on equity. Corn prices in Minnesota are usually $4 to $5 per tonne lower than the Chicago market due to freight differentials.

The combination of an oxygen mandate and the producer incentive has resulted in an industry that grew quickly in the 1990's. The economics provide a good return on capital and there was a ready market for the product, which made financing plants relatively easy.

The Minnesota Department of Agriculture recently published the following summary of the Minnesota ethanol program. It is worth investigating because it is the most comprehensive program in North America.

Background:

The 20-cent ethanol producer payment legislation initially provided the security required by lenders to invest in these small farmer owned ethanol facilities. In addition to opposition from the petroleum industry, bankers were concerned that these plants could not compete in the market with large agribusiness processors. At that time most ethanol production occurred in large corporate mills outside the state. But Minnesota corn prices were among the lowest in the country, which might be an advantage for local processing by farmers.

Although these ventures have been successful to date, margins have been squeezed by periods of record high corn prices and low ethanol prices. It is hoped that ten years of payments will allow plants to retire debt, increase efficiency and to develop new products so they can survive the *competition and price fluctuations in agricultural and petroleum markets. Unique aspects of the ethanol industry made these incentive payments necessary, but our ethanol industry will contribute over $350 million in net annual benefit to the state.*

Since low farm commodity prices are common, these new corn plants may represent a new strategy for the long-range profitability of farmers and farm communities. Vertical integration from the bottom up could allow farmers to participate in the more profitable end of agriculture. Promoting farmer investments in the processing and marketing of other crop or livestock enterprises may not require the high level of state funding as did ethanol. It is hoped that such initiatives can reduce the need for continual funding of farm financial crisis measures and allow farmers to make it on their own.

The main components of the Minnesota Ethanol Program are:

1. *Oxygenated fuel statute that requires state-wide oxy-fuel (ethanol) use,*
2. *The ethanol producer incentive provides payment for ethanol produced,*
3. *$550 million in total corn/ethanol plant project spending for construction and start-up costs.*
    - *$370 million in private sector financing was contingent on local equity capitol.*
    - *$180 million local equity capitol raised by over 8,000 farmers and local businesses.*
4. *$240 million worth of corn is committed for processing annually by local farmers.*

The goals of the program include:

1. *To build a new market for the state's largest crop (corn).*
2. *To develop corn processing/ethanol production facilities in Minnesota.*
3. *To increase the number of New Generation Farmer Coops (NGC).*
4. *To replace 10% of imported petroleum we use for gasoline. ($100 million annual savings)*
5. *To help the Twin City Area meet U.S. EPA standards for carbon monoxide.*

Results to date:

1. *130 million bushels of corn (17% of Minnesota crop) is made into ethanol and other products.*
2. *Minnesota's 14 plants can produce over 220 million gallons of ethanol per year.*
3. *Twelve of Minnesota's 14 ethanol plants are New Generation Co-operatives.*
4. *Nearly 10% of our gasoline is being replaced by ethanol each year.*
5. *The Twin Cities Area met EPA's carbon monoxide standard and has recently achieved "attainment" status. The continued use of ethanol is required to keep emissions low.*

Table 11-2 Minnesota Ethanol Plants & Capacities

City & (plant name)	Capacity Gallons/year	mm. bushel corn/year	Start-up year	New Generation Co-op Members
Marshall (MCP)	30 million	11.0 *	1988	4,000
Morris (DENCO)	15 million	5.5	1991	300
Winnebago (Corn Plus)	20 million	7.4	1994	650
Winthrop (Heartland)	17 million	6.3	1995	502
Benson (CVEC)	19 million	7.0	1996	650
Claremont (Al-Corn)	17 million	6.3	1996	358
Bingham Lake (Ethanol2000)	28 million	10.4	1997	244
Buffalo Lake (MN Energy)	12 million	4.4	1997	325
Melrose (Kraft)	2.6 million	cheese whey	1986	(private)
Preston (Pro-Corn)	18 million	6.6	1998	170
Luverne (Corn-er Stone)	17 million	6.3	1998	201
Little Falls (CMEC)	18 million	6.7	1999	854
Albert Lea (Exol/Agri Resources)	17 million	6.3	1999	496
St. Paul (Gopher State Ethanol)	15 million	5.6	1999	(private)
TOTAL	245.6 mm	89.8		8,750 members

Table 11-3 Minnesota Ethanol Production -vs.- Market Penetration

Year	Production (mm = million)	Estimated Consumption	% Minnesota Ethanol Produced Here
1994	24 mm gal.	125 mm gal.	20% of total
1997	112 mm gal.	177 mm gal.	63% of total
1999	190 mm gal.	200 mm gal.	95% of total
GOAL	240 mm gal.	240 mm gal.	100% of total

New Generation Farmer Co-ops (NGC) may be combined with or converted to limited liability companies or partnerships that are generally designed to:

1. *be built by farmers to process member crops,*
2. *return more cash to farmers than conventional markets would provide,*
3. *be controlled by farmer board members so that farmer profits remains a top priority,*
4. *create a stable source of local jobs and economic development.*

Iowa

Iowa has a very large ethanol production industry. The six plants have the capacity to produce almost three times as much ethanol as would be required for a 10% blend in all gasoline. Iowa also is a very significant corn producing state. There is significant awareness of ethanol in the state as a result of these factors.

The use of ethanol in gasoline is attractive to gasoline marketers due to the 0.26 cents per litre of blended fuel tax incentive offered by the State. There are no oil refineries in the State. Large marketers in the state include BP Amoco, Equilon (a Shell Texaco joint venture), Phillips 66, Sinclair Oil, Conoco, and Citgo.

Illinois

Illinois has the largest ethanol production capacity in the United States. There are four very large plants in the state. There is a 1.875-% sales tax reduction on ethanol gasoline blends that is equivalent to about 0.6 cents per litre of blended fuel. This will provide an incentive to the marketers to use ethanol.

Illinois has the Chicago RFG area that is satisfied by 100% ethanol blended gasoline. The large marketers in the state include BP Amoco, Equilon, Phillips 66, Sinclair oil, Conoco, Citgo, Ashland and Clark. There are four refineries in Illinois.

Ohio

Ohio has an income tax credit for ethanol blended gasolines of 0.26 cents per litre. There are not any ethanol plants operating in the state at this time. A large plant at South Point, Ohio was closed down and dismantled several years ago. The Cincinnati area of the state has opted in to the RFG program and ethanol is used exclusively as the oxygenate in that region. There are four refineries in Ohio.

South Dakota

Three ethanol plants in South Dakota supply all of the state’s ethanol requirements and export some product as well. There is a state producer incentive that pays each facility a maximum of $1 million per year and a tax exemption of 0.53 cents per litre for the use of ethanol blends in the state. There are no oil refineries in the state.

The largest marketers are Sinclair, BP Amoco, Equilon, Phillips 66, and Country Energy, a marketing agencies for two farm co-ops, Cenex and Farmland Industries. Country Energy does offer ethanol blends as part of their marketing program.

Colorado

Colorado has one small ethanol plant processing brewery waste. Colorado was the first state to implement the winter oxygenated fuel program to address high carbon monoxide ambient air levels. The Denver, Boulder, Ft. Collins areas all use 3.1% oxygen that is supplied 100% by ethanol. The program runs from November 1 to February 7 each year.

There are two operating refineries in the state.

New Mexico

New Mexico has one ethanol plant that is not currently operating. There are three refineries in the state. The city of Albuquerque has a requirement for oxygenated gasoline at 2.7 wt % oxygen for November through February. Since the 1993-94 season this has been supplied 100% by ethanol and the typical fuel contains 8% ethanol.

Nebraska

There are seven ethanol plants operating in Nebraska. The state has had active programs to encourage ethanol production in the state. The current program pays 2 cents per litre for the first 38 million litres per year for a three-year period for new plants.

The largest marketers in the State are Sinclair, Phillips, Equilon, BP Amoco, and Country Energy. There are no refineries in the state.

The Nebraska Ethanol Board has a campaign promoting ethanol with a statewide consumer awareness message. The campaign efforts are devoted towards ethanol promotion through educational materials, E-10 unleaded brochures, television commercials, radio advertisements, E-10 unleaded pump labels, mass transit advertising, public service announcements, as well as media and press releases from our office. The campaign's new slogan for ethanol fuel is "E-10 Unleaded Put it in. Drive." The automobile industry, retailers, state patrol, environmental officials, and other organizations reinforce this message.

The Nebraska Ethanol Board developed and distributed an educational curriculum that was sent out to Nebraska educators and students to help promote understanding of the benefits of ethanol production and use.

Nevada

There are no ethanol plants in Nevada and only one very small refinery. The cities of Reno and Las Vegas both have winter oxyfuel programs that run from the beginning of October to the end of March in Las Vegas and October to the end of January in Reno. Both areas are 100% ethanol and the requirement in Las Vegas is for 3.5% wt oxygen, which makes ethanol the only legal oxygenate as MTBE is limited to 2.7% wt oxygen by the US EPA.

Indiana

One large ethanol plant supplies the ethanol requirements in Indiana. There are two refineries in the state. A portion of the state falls within the Chicago RFG area and ethanol supplies the entire oxygen requirement for the RFG.

Utah

Utah has five refineries and no ethanol plants. The Provo/Orem region is a carbon monoxide non-attainment area and uses ethanol to meet the 3.1 wt % oxygen requirement from the beginning of November to the end of February. Ogden is also a non-attainment area but have not implemented an oxyfuels program.

Wisconsin

There is one ethanol plant under construction in Wisconsin. Parts of the state fall within the Chicago RFG program and thus use ethanol in all their gasoline.

Washington

Washington State uses much more ethanol than is produced in the state. Only a relatively small portion of the state is required to use ethanol blends for the winter months. There are four refineries in the state and one of them has utilized significant quantities of ethanol when it has been priced to be competitive to gasoline. Some of this ethanol has been imported from the Caribbean region. The large marketers are Equilon, Chevron, Tosco, Exxon and ARCO.

North Dakota

North Dakota has two ethanol plants and one refinery. There are ethanol production incentives in the state but no additional incentives for ethanol use. The major marketers are BP Amoco, Sinclair, Country Energy and Phillips 66. Country Energy does offer an ethanol-blended gasoline.

Virginia

Virginia has no ethanol plants and one refinery. Parts of the state have opted in to the RFG program, which probably accounts for the high reported use of ethanol.

Critical Success Factors

The top dozen states have either;

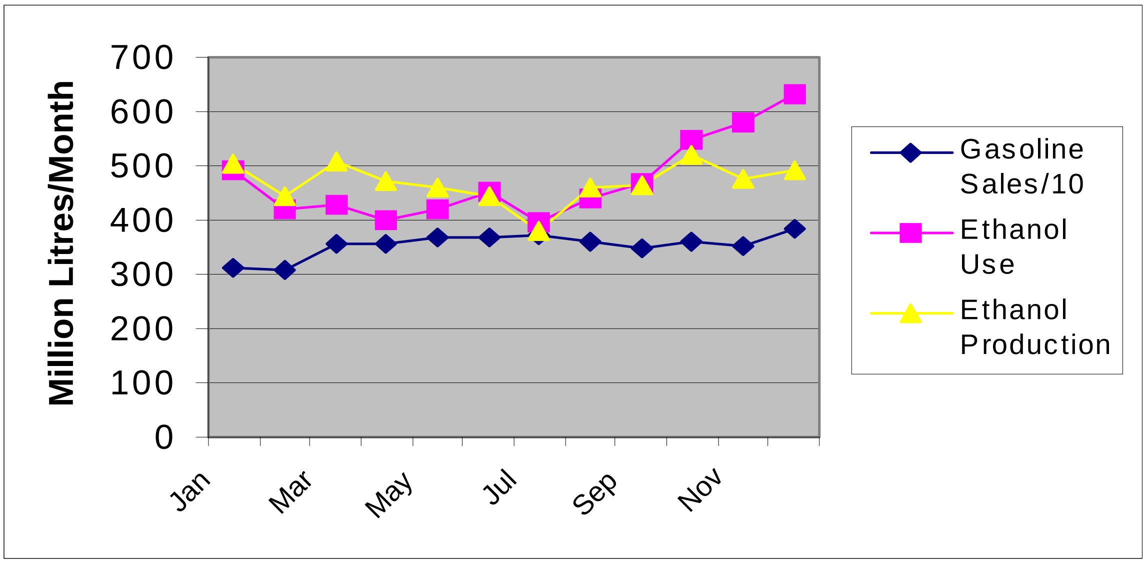
1. a state incentive for ethanol use, which makes ethanol a financially attractive gasoline blending component or
2. a legal requirement to use ethanol or another oxygenate as part of the winter oxy-fuel program, or
3. a requirement to use an oxygenate in the Reformulated Gasoline Program.

This underscores the importance of ethanol economics being favourable for the gasoline refiner or marketer to consider using ethanol. Many of these states do not have oil refineries which means that ethanol is probably taking advantage of the RVP waiver afforded to 10% ethanol blends.

The impact of the winter oxy-fuel program can be seen from the seasonal pattern of ethanol use. In the next figure ethanol production, ethanol consumption and gasoline sales are shown on a monthly basis for the calendar year 1999. The impact of the winter oxy-fuel program is apparent from the increasing ethanol use in the fall months when gasoline demand is actual dropping.

From data presented in section 6 on Environmental Policy and a state by state review it would appear that approximately 22% of the ethanol is used in oxygenated gasoline for the winter oxy-fuel program and Minnesota's mandated program, 42% is used in the Reformulated Gasoline program and 36% is use as an octane enhancer and volume extender. The importance of these three factors in the success of the development of the US ethanol market can not be overestimated.

Figure 11-1 Ethanol Production and Consumption Patterns - 1999



Ethanol production incentives have been successful in increasing ethanol production in Minnesota, Nebraska, and South Dakota. The large ethanol production capacity in Illinois and Iowa is due in large part to the presence of the very large ADM plants in those states.

11.1.2 Historical Ethanol Use

The use of ethanol has changed over the past 20 years in the United States. In the 1980s it was used primarily as a volume extender and octane enhancer, later with the introduction of the oxy-fuel and RFG programs some of the ethanol moved from the lower value extender market to the higher value oxy-fuel and RFG markets. This changing market use can be observed in the following table developed from US DOT data. This table identifies the maximum sales of ethanol blended gasoline between 1980 and 1998 by state and the year that the maximum sales were reached. Lessons can be learned from states that have seen a drop in ethanol use. The data on the last year of a State tax exemption is from the ATA Foundation. This data may not be complete as more states than identified here once offered tax incentives.

Table 11-4 Maximum Historical Ethanol Use

State	Ethanol Blended Gasoline Sales (thousand litres)	Year of Maximum Sales	1998 Sales as a % of Maximum Sales	Year State Exemption for Ethanol Blends was Eliminated
Alabama	1,762,444	1987	6.9%	1988
Alaska	530,455	1996	17.9%	
Arizona	1,236,136	1996	66.0%	
Arkansas	234,375	1990	0.0%	1985
California	6,431,916	1996	65.2%	
Colorado	3,130,184	1996	83.7%	
Connecticut	220,597	1993	59.0%	
Delaware	5,715	1980	0.0%	
Dist. of Col.	1,686	1988	0.0%	
Florida	2,197,556	1985	2.4%	1983
Georgia	359,024	1991	0.0%	
Hawaii	5,334	1981	0.0%	
Idaho	296,473	1991	0.0%	
Illinois	8,020,041	1998	100.0%	
Indiana	3,096,640	1995	69.3%	
Iowa	2,587,263	1998	100.0%	
Kansas	1,064,512	1985	11.7%	1987
Kentucky	2,862,934	1987	4.9%	1986
Louisiana	1,270,787	1986	1.9%	1987
Maine	9,957	1980	0.0%	1990
Maryland	144,819	1997	62.1%	
Massachusetts	61,270	1980	0.0%	
Michigan	2,506,087	1991	50.0%	
Minnesota	8,678,169	1997	99.5%	
Mississippi	188,233	1993	0.0%	
Missouri	1,105,264	1994	25.4%	1996
Montana	42,812	1983	36.7%	
Nebraska	1,405,374	1992	53.2%	
Nevada	632,912	1998	100.0%	
New Hampshire	13,767	1980	0.0%	
New Jersey	598,109	1997	65.5%	1991
New Mexico	994,847	1998	100.0%	
New York	1,077,236	1996	61.8%	
North Carolina	1,446,723	1998	100.0%	1985
North Dakota	246,936	1986	69.6%	
Ohio	8,018,525	1998	100.0%	
Oklahoma	586,100	1982	0.0%	1983
Oregon	1,281,904	1993	41.6%	1993
Pennsylvania	2,601,540	1997	18.8%	
Rhode Island	6,664	1980	0.0%	
South Carolina	386,819	1988	0.0%	
South Dakota	705,594	1994	96.4%	
Tennessee	2,193,258	1988	0.5%	
Texas	2,362,390	1998	100.0%	

Utah	506,308	1998	100.0%	
Vermont	0		N/A	
Virginia	1,757,825	1996	77.7%	
Washington	3,334,353	1993	37.6%	1994
West Virginia	158,679	1992	0.5%	
Wisconsin	2,677,363	1997	45.6%	
Wyoming	227,227	1994	0.0%	1995
Total	81,271,136		65.0%	

Several interesting facts are apparent from the table. The first is that ethanol has been used in all states except Vermont at one time or another. The second is that the implied ethanol demand of 8.1 billion litres is above the maximum ethanol production of 5.2 billion litres in 1998/99. It is also above the industry production capacity of 7.1 billion litres. The third is that there is a strong correlation between the elimination of state incentives and the drop in the use of ethanol. Many of the states reached their maximum ethanol use in the 1980's and the zeros in this table indicate that these states no longer use ethanol.

Even states with high ethanol use such as Nebraska have seen a drop in market penetration. In the case of Nebraska it can be explained by the switch from state support from a tax exemption that encourages the use of ethanol blended gasoline to a production incentive that encourages ethanol production. Each incentive is very different in how it is applied and whom it benefits and it encourages very different behaviour in the market place. Tax incentives encourage market development and production incentives encourage ethanol production.

All of this historical data supports the importance of incentives to provide ethanol with a relative economic advantage for success in the market place. It is also apparent that ethanol use has moved from market to market in search of the highest value use. Today the high value markets are some of the RFG markets, the oxygenated gasoline markets and those states that still provide an economic incentive for the use of ethanol.

11.1.3 Canada

The largest ethanol market share in Canada is in Ontario where Sunoco use ethanol in all of their gasoline. Sunoco have 10% of the service stations on the province and they are above average volume stations. With ethanol also being sold by a number of independent oil companies the ethanol blend market penetration is likely about 15%. The industry began to develop in the province when the provincial ethanol tax exemption was introduced. The total tax incentive available in the province is higher than the US federal incentive and is equivalent to 6.4 cents (US) per blended litre. This is equivalent to those states with the highest market penetration that also have a state tax incentive.

Sunoco have incorporated ethanol into their refinery and take full advantage of the high octane. The Sunoco refinery produces aromatic components for the chemical industry and through the use of ethanol as a gasoline blending component they have been able to increase their production of these high value aromatic materials. This enhances the value of ethanol to this refiner. Not all refiners can take advantage of this opportunity.

In Western Canada the Mohawk experience demonstrates the importance and potential of good communications with the customer. Mohawk was able to take advantage of ethanol environmental properties and its octane increasing capabilities to attract new customers and build market share with customers who were willing to pay more for ethanol blended gasoline. Mohawk did take advantage of some provincial tax incentives that provided a large enough base of customers to reach a critical size in terms of ethanol production economics.

11.2 BIODIESEL EVALUATION

In Canada biodiesel is still very much in the Phase 1 stage of development. Biodiesel proponents have not been successful in gaining any tax incentives that would provide an economic impetus for development. Neither have they been successful in finding niche markets that would be willing to pay more for biodiesel. There is some activity underway to examine very low levels of biodiesel blending to take advantage of the fuels excellent lubricity properties. It remains to be seen if this will result in a market that is large enough to warrant production of biodiesel in Canada.

Biodiesel in the United States in is the late Phase 2 stage. There are some commercial plants for the production of biodiesel but the data would indicate that they have not been operating at full capacity. On the marketing side the industry admits that most biodiesel use up until late 1999 was in demonstration trials. In 2000 there has been some commercial applications of low-level biodiesel blends and some penetration into the government mandated alternative fuels market area. This is a very interesting strategy that is discussed further below.

There was a study (Webb) performed in 1995 by R.F. Webb Corporation for the National Biodiesel Board. The objectives of the study were;

- Examine tax concessions potentially available from federal or state agencies for the use of biodiesel.
- Quantify the benefits of biodiesel by reference to the costs of alternative ways to reduce emissions of particulates, NOx, CO, and sulphur oxides priced by electric utilities.

The accomplishments were;

- Sought to accelerate consideration of equity in the treatment of biodiesel in the provision of excise and income tax credits now made available to bio-alcohol fuels.
- Promoted extension of the mandates in CAAA-90 and EPAct to heavy-duty diesel vehicles.
- Recommend expanded tax credits for biodiesel research, development, and demonstrations.
- Suggest the promotion of the clean fuel aspects of biodiesel through educational programs involving the public, engine and vehicle manufacturers, and state, local, and federal government agencies concerned with the environment, energy, and taxation.

The industry appears to have focused on EPAct and the promotional aspects of the accomplishments of this work and have not implemented the lobbying effort necessary to achieve any federal tax incentives for biodiesel.

The *Energy Policy Act* (EPAc*t)* was passed in 1992 to accelerate the use of alternative fuels in the transportation sector. The U.S. Department of Energy's primary goals are to decrease the nation's dependence on foreign oil and increase energy security through the use of domestically produced alternative fuels. DOE's mission is to replace 10% of petroleum based motor fuels by the year 2000, and 30% by 2010.

Federal, state and alternative fuel provider fleets are currently mandated by EPAct. Fleets that own, operate, lease or control at least 50 light-duty vehicles (8,500 lbs. or less) in the United States are covered. Of the fleet vehicles, 20 or more must be operating primarily within any affected area (see below). The vehicles must also be centrally fueled or capable of being centrally fueled. A fleet must meet all three requirements to be "covered" by EPAct. Municipal and private fleets are currently being considered for mandates and an advance notice of proposed rulemaking (ANOPR) was issued in April of 1998. DOE was to finalize this rulemaking by January 1, 2000.

Only the Metropolitan Statistical Areas (MSA) and Consolidated Metropolitan Statistical Areas (CMSA) are cities or areas that had a population of at least 250,000 at the time of the 1980 US census are covered by the act. Vehicles that are exempt from the mandate include law enforcement vehicles, emergency vehicles, non-road vehicles and vehicles used for product evaluations and testing.

Many of the vehicles that are covered are heavy-duty vehicles for which there are very few alternative fuel options. A 20% biodiesel blend qualifies as an alternative fuel under the regulations.

The higher fuel cost for biodiesel is more than offset by the fact that other alternative fuel options for heavy duty applications have higher vehicle costs and in some cases a higher refueling infrastructure cost. On a total ownership basis the biodiesel vehicles are the least expensive means of meeting the regulations. The biodiesel is more expensive than petroleum diesel so this economic advantage is only applicable to mandated fleets.

EPAct is far from reaching its goals of 10% petroleum substitution in 2000. A recent review of the program (GAO 2000) found that the program was not meeting its goals principally because alternative fuel vehicles have significant economic disadvantages compared to conventional vehicles. Other factors that were identified include a lack of refueling stations. One of the criticisms of the program is that it mandates vehicle purchase but not alternative fuel use and the use of flexible fuel vehicles satisfies the purchase requirements even if they are not operated on alternative fuels. Since the biodiesel can be used in a conventional diesel engine the biodiesel program will earn vehicle credits for fuel purchases. The success of this program should be followed closely since the commercial success of biodiesel depends on it.

The EPAct requirements may be expanded to municipal fleets in the future. If this happens it will broaden the potential economic market for biodiesel.

11.3 Ethanol Growth Scenarios

Two growth scenarios for biofuels were considered for the study, a modest growth rate of 10% over five years, this is equivalent to an annual growth rate of 1.9%, and a ten-year target of 5% of motor fuel consumption. If ethanol is substituted just for gasoline on an energy equivalent basis this would require about 2.9 billion litres in Canada and 37 billion litres of ethanol used in the United States. Over a ten-year period this represents an annual growth rate of 31% in Canada and 21% in the United States.

11.3.1 Moderate Growth Scenario

The moderate growth scenario for ethanol is likely to be achieved in Canada and the United States with the continuation of existing policies. Growth in the demand for ethanol in the US over the period 1994 to 1999 averaged 6.3%. The growth rate in Canada was even higher but was essentially due to just one plant. This growth rate is far above that required to meet the scenario.

The modest scenario would add 20 million litres per year of additional capacity in Canada. There are several ethanol plant projects under development in Canada at the current time. It is highly likely that at least 60 million litres of annual capacity will be added within five years and likely that as much as 125 million litres of annual capacity will be added. At least one of the projects has a refiner as a customer for the ethanol, only the financing remains to be completed.

The modest scenario in the US will require 490 million litres of production to be added. In the United States there are currently four plants under construction that will add 437 million litres of capacity. There are a large number of proposed plants under consideration (Bryan and Bryan). The proposed plants are shown in Table 11-5. Many of these plants are in the financing stage. It is likely that not all will be able to raise the necessary finance. This may be especially true for the cellulosic ethanol plants. The BC International plant in Jennings and the Masada plant in Middletown have been in the financing stage for several years.

Table 11-5 Proposed US Ethanol Plants

Company	Location	Feedstock	Size Million litre/year
BC International	Jennings, LA	Bagasse	76
American Agri-Tech Corp	Great Falls, MT	Wheat, Barley	113
Lower Caskaskia Econ Dev BD	Lower Caskaskia, IL	Corn	378
DFI. Agri-Energy Inc.	Eastern NC	Sweet Potatoes	227
BC International	Gridley, CA	Rice Straw	76
Neliegh Project	Neleigh, NE	Corn	57
Arkenol	Sacramento, CA	Rice Straw	45
Masada	Middletown, NY	Municipal Solid Waste	38
Sustainable Energy Dev	Central Region, OR	Wood Waste	113
Pacific Rim Ethanol	Moses Lake, WA	Grain	151
Sealaska	Southeast Region, AK	Wood Waste	30
Cascade Ethanol	Clatskanie Falls, OR	Grain	302
Northern Growers	Milbank, SD	Corn	132
Michigan Project	Central State, MI	Corn	113
Standard Energy	Philadelphia, PA	Municipal Solid Waste	57
Green Leaf	Platte, SD	Corn	57
City of Brighton	Brighton. NJ	Corn	57
Pratte project	Pratte, KS	Corn/Milo	57
Iowa	Central Iowa	Corn	57
Tri-county Corn Processors	Rosholt, SD	Corn	57
Collins Pine/BCI	Chester, CA	Forest Thinnings	76
SE Missouri/Delta	SE Missouri, MO	Corn	113
Black Hills	Black Hills. WY	Forest Residue	45
Total			**2,351**

There is also the possibility of expansion at existing plants. Urbanchuk (Aus Consultants) estimated that the expansion potential of existing plants amounted to 4 billion litres per year and it could be added within 4 years. It was indicated that some of the largest existing ethanol producers had shown a willingness to expand if the ethanol demand increased substantially.

The relatively well defined state of proposed plants in the United States is due to the problems with MTBE. Most of the MTBE used in the United States is used in the Reformulated gasoline program to meet the requirement of oxygen in the gasoline. The US EPA has announce that it wants to reduce the use of MTBE because of ground water contamination problems caused in large part by leaking underground tanks. This move follows similar moves by the State of California. At the same time the requirement for oxygen in gasoline is being revisited. There are some who suggest that clean burning gasoline can be made without oxygen and the oxygen requirement should be eliminated. With over 40% of ethanol production going into RFG and the potential to supply essentially all of the oxygen requirement of RFG instead of the current 15% this is a critical issue for the ethanol industry in the United States. There is a wide range of potential outcomes ranging from a 40% reduction in market size to a tripling of the market for ethanol. Given the strength of the ethanol movement in the United States a reduction in the market would seem unlikely. It is also unlikely that all reformulated gasoline could meet the standards without oxygen, at least in the near term so the most likely outcome will be some growth in the ethanol market over the next five years. The magnitude of that growth can not be predicted.

It is highly likely that the modest growth scenario for ethanol will be achieved in both Canada and the United States.

11.3.2 High Growth Scenario

The high growth scenarios for ethanol in Canada and the United States will require the production and use of 2.9 billion litres per year and 37 billion litres per year respectively. These are very significant increases, 31% per year in Canada and 21% per year in the United States from the current scenario.

In Canada the ethanol production target could be met from the conversion of about 53% of the current wheat exports even with no growth in supply. In reality the supply of feedstocks is likely to continue the annual increase in yield of about 1.5% per year. If this increase in the corn and wheat supply was converted to ethanol then only about 17% of the wheat exports will be required for ethanol production. There is significant interest in ethanol from lignocellulosics in Canada and a very large resource base. If the development of the technology continues then there will be the capability of supplying some of the required ethanol from lignocellulosics. The target, however, could be met without the lignocellulosic technology if required.

There would have to be an expansion of ethanol production capacity in the country. Ethanol use is not currently economic in all parts of the country since the Federal incentive alone is not sufficient to offset the higher cost and not all of the provinces offer an ethanol incentive. The incentives that are in place do not all have guarantees that they will stay in place long enough for investors to recover their investments. These two issues, the inconsistent incentives across the country and the lack of a guarantee that the incentives will stay in place, will need to be resolved before an expansion of the industry can be undertaken on the scale required for the high growth scenario.

The consumption of 2.9 billion litres in Canada would require many new players in the marketplace. This ethanol volume is equal to about 75% of the country’s gasoline containing 10% ethanol. Either every gasoline retailer in those provinces with ethanol incentives would have to have all of their gasoline contain 10% ethanol or the incentives would have to be added to those provinces who do not have them so that three quarters of all retailers could economically sell ethanol blended gasoline. If all gasoline in a region were to contain ethanol then some savings on distribution costs could be realized since extra tankage for a special blending gasoline would not be required.

The increased penetration of E85 vehicles in the marketplace could consume large amounts of ethanol. The economics of E85 are not competitive with gasoline in Canada or the US as shown in an earlier section. If the price of ethanol were reduced relative to crude oil so that E85 was competitive then the ethanol price would be very attractive to a refiner and refiners would have to use ethanol to be competitive in the retail market place.

The production of 37 billion litres per year of ethanol in the United States would require 92 million tonnes of corn. This is almost twice the level of current corn exports from the United States. If the production of corn continues to grow at 1.5% per year for 10 years then the corn requirement could just be met by the current ethanol use and the total US exports. The feedstock supply situation in the United States is not as plentiful as it is in Canada and it is highly likely that lignocellulosic ethanol would be required to meet this level of ethanol production. The continued development of this technology is thus critical to the supply of ethanol in the high growth scenario in the US.

On the demand side ethanol will have to penetrate many new markets to reach 37 billion litres per year. As in Canada, 75% of the gasoline would have to contain 10% ethanol. Reformulated gasoline has an oxygen requirement of 2% wt., even if all gasoline sold in the US were reformulated at the 2 % wt. level that would create a demand for about 23 billion litres of ethanol. Much of the current debate in the US over phasing out MTBE revolves around essentially creating a mandate for ethanol. There appears to be a great political reluctance to do this. One of the more persuasive arguments has been the potential impact of a low corn crop on gasoline prices. With the very large increases in gasoline prices encountered this year the public is very sensitive to the issue.

The proposed amendments to the Clean Air Act that is moving through the process and would include a requirement for a renewable fuel content in all motor fuel is projected to create a demand by 2011 for 13 to 16.7 billion litres of ethanol and biodiesel. This act, which has yet to be passed, envisions a potential; demand of less than half of the high growth scenario considered here. The proposal is being supported by the Renewable Fuels Association and the National Corn Growers Association (RFA, 2000).

Without a mandate for ethanol in gasoline the only way to reach 37 billion litres would be for the price of ethanol to be very low compared to gasoline so that refiners have to use ethanol to be competitive. There are two factors that work against this scenario. The first is the volatility in the price of crude oil and the second is the lost tax revenue to governments. For ethanol to be very competitive with gasoline the price of crude oil needs to be above $25 per barrel with corn prices at $2/bushel and the existing tax incentives need to be in place. Under these conditions the ethanol producers can earn a respectable return on their investment and the gasoline retailer can obtain ethanol at a competitive price. These conditions have historically not lasted long and thus many refiners would need to be convinced that high crude oil prices would last before they make a commitment to ethanol. At $2/bushel corn producers are not making an adequate return and thus volatility in the price of corn also creates uncertainty that ethanol will remain competitive with gasoline. The development of a cost competitive cellulosic ethanol industry may add stability to the ethanol cost and encourage the expansion of the ethanol market.

Even under the opportunistic corn and oil price scenario detailed above there is still a need for tax incentives. The magnitude of the incentive becomes very large with increased market penetration. At 37 billion litres and adjusting for the energy content of ethanol the lost tax revenue becomes $13 billion per year. A portion of this revenue comes from the fund that is used to maintain the federal highway system. A highway system in need of maintenance is also a sensitive political issue and ways to fund the ethanol tax incentive without impacting the highway system would have to be developed. The State of Ohio (NCSL) is leading an effort to resolve this issue as described below.

As reported in the Cleveland Plain Dealer on August 28, 2000, the increasing use of ethanol in gas sold in Ohio is having the unintended effect of cutting into federal funds the state gets for road and bridge projects, according to the Ohio Department of Transportation. Ohio would have received $165 million more in federal highway funds in 1999 if there were no ethanol in gasoline sold in the state. In response, state officials are lobbying Congress to change the highway funding formula so that cleaning the air through the use of gasohol does not penalize Ohio's road construction budget.

Ethanol, derived largely from corn, is added to gasoline to make it burn cleaner and reduce air pollution. Thirty-eight percent of the gasoline sold in Ohio last year contained 10 percent ethanol, making the state the second-biggest user of ethanol in the country. To encourage its production and use, the federal government taxes ethanol-blended gasoline, also known as gasohol, at 5.4 cents less than regular gasoline. But 3.1 cents of that tax goes to the federal general fund, not the Highway Trust Fund. Even though Ohio is selling no less gasoline, it is paying lower taxes and therefore, getting less money back from the federal government in the form of transportation construction grants

If the lignocellulosic ethanol development program is successful and the ethanol costs can be reduced to 20 cents per litre as projected by NREL then there will be a far greater likelihood of significant market penetration in both Canada and the United States.

11.4 BIODIESEL GROWTH SCENARIOS

The biodiesel growth scenarios are much more difficult to analyze because of the early stage of development of the industry.

11.4.1 Moderate Growth Scenario

In Canada there is no biodiesel being used so the 10% growth rate over five years is not an appropriate measure. The issue in Canada is whether biodiesel can move beyond the Phase 1 development and into Phase 2, where there may be some trials and demonstration projects happening. There are some farmer groups who are trying to raise the profile of biodiesel in Canada both in Western Canada (Saskatchewan Canola Development Commission) and Eastern Canada (Ontario Soybean Growers). The Canadian Renewable Fuels Association also represents biodiesel. These groups have made little progress over the past five years. There are several factors that currently could give them a higher profile and result in progress. These include:

- Higher crude oil prices
- Concern over greenhouse gas emissions
- Concern over particulate emissions from diesel engines
- The movement toward very low sulphur diesel fuel
- Low agricultural prices
- Biodiesel developments in the United States

There is a need for tax incentives to reduce the economic disadvantage to petroleum diesel fuels. The federal tax on diesel fuel is only 2.6 cents (US) per litre in Canada. The elimination of this tax would not be enough to reduce the economic disadvantage of biodiesel. The Federal government in Canada is running a fiscal surplus, as are some of the provinces. There is likely to be less resistance to tax incentives for low greenhouse gas fuels than there was in the past when governments were in a deficit position. The governments' fiscal position will make it easier to raise money for research and development initiates, although there is currently no government R&D for biodiesel in Canada.

With biodiesel just moving into the commercial phase in the United States it is difficult to get a baseline for the 10% increase over five years. With a current biodiesel use of somewhere between 5 and 10 million litres per year the modest growth scenario is quite feasible. Biodiesel production capacity in the United States is considerably higher than this and the low levels not being feedstock restrained the only impediment to biodiesel growth is market acceptance. The cost of biodiesel is too high for most mass markets but for EPAct fleet applications the fuel may be the most economic alternative fuel available on a total cost of ownership basis. Penetration of EPAct fleets and environmentally sensitive fleets should allow the modest growth scenario to be achieved.

11.4.2 High Growth Scenario

Canada uses 15.1 billion litres per year of diesel fuel for road, rail and marine applications. The high growth scenario would require the production of 755 million litres per year of biodiesel. This is less than the 2.7 billion litres of biodiesel equivalent oil that is exported in the form of oil or oil seeds each year. It is difficult to envision a market driven scenario where the industry could move from zero to 755 million litres per year in ten years. Even with the elimination of the federal and provincial diesel taxes there will still be an economic disincentive to using biodiesel in Canada.

Canada has never required the addition of any component to gasoline or diesel fuel. The regulation of fuel quality and fuel composition is a provincial jurisdiction and the federal government can only require the removal of fuel components on the basis of health risks. Thus lead, benzene and sulphur in fuels have been regulated federally. Any biodiesel mandate would have to be mandated provincially and there is no precedent for such a move in Canada. It is therefore difficult to envision any scenario that would see the high growth scenario met in Canada.

The total sales of distillate fuel oil in the US in the 1998/99 fiscal year were 200 billion litres. There were 122 billion litres used for on and off road highway diesel fuel. Five percent of the road transportation volume would be 6.1 billion litres per year and five percent of the total distillate use would be 10 billion litres per year. The total available exports of vegetable oils and animal fats are equivalent to 3.3 billion litres per year of biodiesel. The high growth scenario in the United States is therefore feedstock constrained.

There may be the potential for increasing oilseed production in the US but this would likely come at the expense of acreage planted to corn. The simultaneous expansion of the ethanol market and the biodiesel market will be feedstock constrained.

The US DOE (NREL 1994) did have a program that investigated the production of aquatic plants (micro algae) to produce the oil for biodiesel production. The effort has not been carried through to the demonstration phase yet.

Expansion of the industry up to the level of the available resource will be difficult with the economics of the fuel. Tax incentives of 20 cents per litre are required for biodiesel produced from the least expensive feedstock, yellow grease, and 50 cents per litre for product produced from soy oil, to reduce the cost of biodiesel to the equivalent price of petroleum diesel fuel. Tax incentives of this magnitude will likely be difficult to obtain.

12. CONCLUSIONS

The biofuels ethanol and biodiesel must be considered separately when conclusions are developed as to the state of development of the biofuels industry in North America. The two fuels are at different stages of their development and there are significant differences between Canada and the United States and even within countries.

12.1 ETHANOL

Ethanol has been used as a gasoline blending component for twenty years in both Canada and the United States. The industry has developed continuously in both countries since 1980 and can be considered to be a commercial phase. In both countries the economic viability of the industry is dependent on the existence of favourable fuel tax treatment. The vitality of the industry is dependent on the relationship between feedstock prices (primarily corn), oil prices and tax incentives.

In recent years the profitability of ethanol producers has been marginal creating little incentive for new producers to enter the market except in certain regions, such as Minnesota, that have provided additional incentives for ethanol producers. At the same time ethanol selling prices have not been low enough to increase its use in gasoline except in those areas where oxygen is required in gasoline. In some years the low oil price has been the primary factor impeding development, in other years high feedstock prices were the primary factor and some years uncertainty about the duration of tax incentives has been the primary impediment.

12.1.1 United States

The federal tax incentive of 14.3 cents per litre is the primary driver behind the development of the US ethanol industry. The level of the incentive combined with oil at $20 per barrel requires corn to be priced at $2.30 per bushel in order for ethanol to be equal to the price of gasoline and the ethanol producer to recover their cost of capital. These conditions do not allow for a healthy growing industry. The current situation, with oil above $30 per barrel, and corn prices at $1.80 per bushel the ethanol industry can add new production capacity profitably and price ethanol to the gasoline refiners and marketers low enough to be attractive and develop new markets. Both corn and oil markets are very volatile which adds uncertainty to the ethanol business.

The historical patterns of ethanol consumption in the US emphasize the importance of economics in a gasoline marketers decision process. When states have eliminated their state tax incentive ethanol consumption in that state has dropped almost immediately. As many as 30 states once had state tax incentives in addition to the federal incentive. That has been reduced to six states without restrictions. Ethanol penetration in those states is well above the national average.

As the value of ethanol as a gasoline octane enhancer or volume extender has been reduced, by eliminating state exemptions, two federal programs that require oxygen to be added to gasoline have created new ethanol demand. The winter oxygenated gasoline program, designed to reduce carbon monoxide levels in ambient air, now accounts for about 22% of ethanol demand and the Reformulated Gasoline Program, designed to reduce ozone concentrations accounts for 42% of ethanol demand.

There is some uncertainty about the growth prospects for the ethanol industry in the US. There is optimism due the higher oil prices and low corn prices. Profitability of ethanol producers is probably at an all time high. There is concern about the continued requirement for oxygen in gasoline. The demand in the winter program continues to slowly decline as more and more areas meet the ambient carbon monoxide standards and are removed from the program. The oxygen requirement in the RFG program is met primarily through the use of MTBE, which is under attack from ground water contamination problems. There is the possibility that the oxygen requirement in RFG could be eliminated which may reduce the demand for ethanol. Recent developments in the US Senate may create a requirement for renewable fuel content in US motor fuel that could eventually create a demand for 13 to 16 billion litres of ethanol and biodiesel by 2011. This proposed bill has several more steps to pass through before it becomes law.

In spite of the uncertainty it is highly likely that the modest growth scenario of a 10% growth in five years will be achieved. This conclusion is reached from a consideration of historical growth patterns and new ethanol plants under construction or development. If oil prices remain above $25 per barrel the possibility of achieving this growth rate is almost assured.

The high growth scenario of 5% of gasoline demand supplied by ethanol by 2010 will be difficult but not impossible to achieve. The production of 37 billion litres per year of ethanol from corn will require the use of all corn exports plus all of the anticipated growth in corn production from higher yields. This is not a likely scenario and thus the conversion of lignocellulosic materials to ethanol will be required to meet the supply target.

Lignocellulosic ethanol productions costs are currently estimated to be higher than production costs using corn. The US DOE has an extensive R&D program underway to lower production costs. This program must be successful before lignocellulosic ethanol is commercially viable. Lignocellulosic ethanol is therefore a critical success factor to meet the supply requirements of the high growth scenario.

The demand side of the high growth scenario is not likely to happen with the current market drivers. The elimination of MTBE from the gasoline pool may create a demand for up to 13 to16 billion litres either through a continuation of the oxygen requirement in gasoline or through a requirement for a renewable component of motor fuel.

The high growth scenario would require 10% ethanol in about 75% of US gasoline. Given the positions of the oil industry this is unlikely to happen voluntarily. An alternative would be a rapid expansion of the E85 infrastructure. The value of ethanol in E85 is lower than it is in E10 and while ethanol is marginally viable when used in E10 it is at an economic disadvantage in E85. E85 is therefore an unlikely means of creating significant additional ethanol demand.

The high demand scenario will cause increased concern on the magnitude of the tax incentive for ethanol. Even though the incentive is a federal measure it impacts on how much federal money is delivered to each state for highway construction and repairs. There are already some states that suffer a measurable loss of highway funding due to high ethanol use in the state. These states are looking for changes to the funding mechanisms to alleviate this problem.

Concern over greenhouse gas emissions and the Kyoto protocol is not a driver for ethanol in the United States at the current time. This is probably due to both general inaction on GHG and the small improvement that US ethanol represents over gasoline. Many US ethanol plants use coal to generate their energy and this reduces the potential GHG benefits of ethanol.

12.1.2 Canada

The development of the commercial ethanol industry in Canada has paralleled to a certain extent the US industry. The existence of tax incentives has made ethanol economically viable in some regions of the country. In Canada a combination of federal and provincial incentives is required since the federal incentive alone is less than half the US federal incentive. The need for two incentives and the fact that the federal incentive was not implemented until 1992 has resulted in the industry in Canada being smaller on a per capita basis than it is in the US.

In the Province of Ontario the combined incentive is 16.5 cents per litre of ethanol. With ethanol production costs and gasoline costs being the same in Canada and the United States the slightly larger incentive results in a more viable industry than in the United States. The major ethanol marketer in Ontario, Sunoco, has also integrated the use of ethanol into its refinery and has found ways to maximize the value of the ethanol that it uses. Sunoco also has an excellent communications and marketing program for its ethanol blended gasolines. Sunoco's combined refining and marketing program for ethanol is probably the best in North America and should be used as a model for other refiners and marketers.

There are no programs than have mandated the addition of oxygen to gasoline in Canada and created a demand for ethanol. Environmental awareness is high in Canada and the two largest marketers of ethanol in Canada have both promoted the environmental benefits of ethanol blended gasoline with some success. Concerns over GHG emissions appears to be higher in Canada than the United States and since Canadian ethanol plants are fuelled by natural gas the greenhouse gas benefits of ethanol are greater in Canada than the US. Expanded use of ethanol from grain and ethanol from lignocellulosics is being considered as part of a national implementation plan to address Canada's commitments under the Kyoto Protocol.

The modest growth scenario is likely to be achieved in Canada with the existing environment and programs. There are plans for the expansion of ethanol production capabilities in Canada and some of the proposed plants have agreements with refiners for the sale of the ethanol. Only the financing must be completed for these plants. The lack of a guarantee on the duration of the tax exemptions creates uncertainty for lenders and makes financing difficult.

The high growth scenario is not feedstock constrained in Canada. The combined growth in production of corn and wheat combined with the level of wheat exports is more than sufficient to produce 2.9 billion litres of ethanol required. In addition Canada has significant resources of lignocellulosic residues, and marginal agricultural land suitable for growing crops such as switchgrass.

Like the United States the high growth scenario is likely to be constrained by the market. The gasoline market in Canada is concentrated and dominated by three integrated oil companies. These companies have shown little desire to integrate ethanol into their refining and marketing systems. With 10% ethanol being required in 75% of Canadian gasoline these companies would all have to use ethanol throughout their systems to meet the high growth scenario. Without government intervention this is not likely to happen. Furthermore there is no precedent in Canada for prescribing the addition of gasoline component.

12.2 BIODIESEL

The biodiesel industry in North America is not as well developed as the ethanol industry. There are also differences in the stage of development between the United States and Canada.

12.2.1 United States

The US biodiesel industry is in the late stage of Phase 2 development. It is about to become a commercial industry. There has been substantial support from agricultural organizations and there have been commercial champions who have built plants to supply the anticipated biodiesel demand. This has been accomplished without widespread tax incentives. The industry has spent considerable effort to develop niche markets for biodiesel. The primary market that is expected to drive the commercial development is the requirement for federal and state agencies to purchase alternative fuel vehicles. Biodiesel has become qualified under that program and it may offer the lowest cost of ownership for fleets with heavy-duty vehicles. The costs will be higher than petroleum diesel but lower than other alternative fuels.

In the mass market for diesel fuel biodiesel is at an economic disadvantage to petroleum diesel. This is due to the higher cost of production and the lack of tax incentives.

The modest growth scenario is likely to be achieved due to the small base of current biodiesel use. There are sufficient feedstocks to make this happen.

The high growth scenario is feedstock constrained in the United States. The exports of vegetable oils and animal fats amounts to about half the feedstock required for the high growth scenario. The potential for increasing oilseed production exists but it would likely be at the expense of corn production. The simultaneous expansions of the ethanol and biodiesel industry will definitely be feedstock constrained.

The market demand for the high growth case can not happen without financial incentives to equalize the price of biodiesel and petroleum diesel.

12.2.2 Canada

The biodiesel industry in Canada is still in Phase 1 of its development. There have been a number of studies done and some demonstrations but little development beyond that. There is support from agricultural organizations and some interest by diesel fuel marketers but to date there has been no commercial champion, no company willing to make an investment in production capability or market development.

Biodiesel is at an economic disadvantage compared to petroleum diesel since it costs considerably more to produce and there are no tax incentives. The magnitude of the tax incentives required are higher for biodiesel than they are for ethanol and the taxation on diesel fuel is lower than it is on gasoline in Canada. These two factors make the implementation of an economically viable tax incentive for biodiesel politically difficult.

With no use of biodiesel in Canada with moderate growth scenario of a 10% increase over five years is not measurable. Without the presence of a commercial champion it is difficult to envision the development of an industry and a commercial champion is unlikely to emerge without a reasonable tax incentive.

In Canada the high growth scenario would not be feedstock constrained as sufficient oil is exported in the form of oilseeds or as oil to meet the 5% requirement. The high growth scenario is market limited and the same factors that influence the moderate growth case apply here.

12.3 Critical Success Factors

Several critical success factors have been identified from the development of the biofuels industry in North America. They are slightly different for ethanol and biodiesel and are presented below.

12.3.1 Ethanol

The ethanol industry has been able to develop to the stage it has in North America in large part due to the support of the agricultural producers. These players have had enough influence on the political process to enact tax incentives and have them extended from time to time in spite of pressure on governments to reduce deficits over the past twenty years.

In addition to the grass roots agricultural support there have been commercial champions in both Canada and the United states who have been willing to invest in ethanol production facilities and in the development of an ethanol market.

In the United States the regulation of gasoline quality and the requirement for the addition of oxygen to some gasoline has increased the demand for ethanol.

In Canada the promotion of ethanol's environmental benefits has aided in the market development process.

12.3.2 Biodiesel

The critical players in the development of biodiesel in the United States have been the agricultural producers. In addition there have been commercial champions willing to invest in biodiesel production facilities in advance of market development. In Canada the commercial champions are absent from the equation and biodiesel appears to be stalled at Phase 1 of its development.

Regulations mandating alternative fuel use appear to be opening up market development opportunities for biodiesel in the US.

The lack of widespread tax incentives for biodiesel will make the development of mass-market opportunities very difficult to achieve.

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